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FREEDOM IN THE GOOD SOCIETY

WHATEVER may be the outcome of the proceedings of the Commission on Human Rights of the Economic and Social Council of the United Nations meeting at Geneva, the very existence of that Commission is a reminder of the many threats to human freedom which beset the world to-day. Mr. Bevin's recent speech, focusing sharply the rift between the U.S.S.R. and Western Europe, indicated that to some extent it is due to the different views of human rights arising from the different emphasis placed on the community and the individual. Again and again the events he surveyed testified to the truth that tolerance and respect for human personality are not only the essence of democracy but also the essence of civilization itself.

The issue of freedom in political affairs is closely related to the issue of freedom in science. Even on this question of tolerance, it has been emphasized in recent discussions on operational research how important are the contributions which minority groups or individuals have made in developing views opposed to the accepted or orthodox opinions of the majority ; and the dangers which secrecy in research offers to the advance of science have been made abundantly plain in the debate on the control of atomic energy.

Nor is this all. As the debate in the House of Commons on the Atomic Energy Act of 1946 revealed, the fundamental problem is the extent to which powers of control shall be entrusted to the Government, and the way in which those powers are exercised. It is a problem in government, above all a problem in democracy ; and it is a disturbing reflexion that, in one sphere after another, even in democratic Britain, controls have been imposed and administered in ways likely to impair respect for human personality and to arouse the opposition rather than to secure the consent of the governed. In its handling of the fuel crisis, the petrol situation, the new health service and the question of a wages policy, the Government has used too often the methods of the totalitarian State rather than those of a democracy ; and under the forms of parliamentary government has shown a spirit of intransigence which, as Sir Ernest Barker points out, is fundamentally opposed to the spirit and temper of accommodation which is the touchstone of democracy.

In his recent book, "Science and Freedom"*, Dr. Lyman Bryson says that when a decision he could make for himself is taken out of the hands of a citizen, his government has failed in democratic operation. That observation is highly significant in regard to the threats to freedom just indicated, and especially in regard to the question of the structure of the public corporations which the programme of nationalization in Britain has brought into prominence and made so urgent and vital. Equally pertinent reading to-day are those general principles and recommendations based on experience at a Japanese re-location camp which Lieut.-Commander A. H.

* Science and Freedom. By Lyman Bryson. Pp. xi+191. (New York : Columbia University Press ; London : Oxford University Press, 1947.) 15s. net.

Leighton has embodied in his book "The Governing of Men"*. In both books there is much to be pondered by all who are concerned in any way with problems of human freedom, and with the urgent question of developing institutions in which those needs can best be served both in the field of science and in those of social, economic and international affairs.

Dr. Leighton places his first emphasis on the need for great understanding on the part of an administration faced with a community under stress. That, rather than great remedial change, is the important factor; and there could scarcely be a more severe indictment of both the great political parties of Britain during the past three years. Then he suggests that an administration should select means that are readily workable, not only in terms of the causes of the stress but also in terms of the way people are reacting, in terms of their habitual attitudes and beliefs, and in terms of their customary forms for dealing with each other. The channels of assent can never be dug too deep, whether we are concerned with legislative or administrative action. Here Dr. Leighton emphasizes the difference between human or social engineering and engineering in the mechanical or physical sense. Not merely does he point out that no alteration of policy should be arbitrary, and that what alterations are chosen should be carefully explained so that those concerned recognize their advisability, but equally he reminds us that administrators should not be too afraid of admitting they have been in error.

Dr. Leighton's fourth conclusion that, wherever possible, plans for social change should be tried out first on a small scale in a segment of the community, and also his fifth, that the administration must identify and deal with the basic social units of the communities, are in line with the results of the researches which Dr. Elton Mayo expounds as the basis of his work "The Human Problems of an Industrial Civilization". Nor can it be charged against Dr. Leighton that he is too conservative; for in his sixth conclusion he recognizes the opportunities which a time of stress affords a skilful administration for guiding constructive developments and even securing extensive changes which might be impossible or extremely difficult in normal times.

What pervades the remaining four of his conclusions most strikingly is the emphasis placed on the need, already indicated, for securing the consent of the governed. The great promise he holds for men and their government is in a fusion of administration and science to form a common body of thought and action, realistic both in dealing with everyday needs and in discovery and improved practice.

Dr. Bryson's book is essentially an essay on the theme that the scientific method can be used to understand human behaviour, and that scientific knowledge can be applied to the management of human affairs. He would use social engineering to solve the problem of setting up the conditions of freedom, but not to determine what men shall do with freedom when they get it. His thesis is that science can be used as one of the tools by which to establish the conditions in which human powers may realize human values. He believes that the conditions of freedom are the conditions in which the creative powers of man, and all the other creative factors of Nature to which man has access, can work best; and he suggests that if we can inspire the behaviour of man with a real desire for freedom and creative change, we can build social structures that will make creative change not violent and costly but peaceful.

Dr. Bryson recognizes that the social structures of a free society are complex, and he insists that our primary concern should be with the condition and techniques of freedom—the content of freedom rather than the use men make of freedom. Once again we find the emphasis laid on the educational aspect of the process of government, on the dangers of centralization of power and the revolutionary character in this context of the conception of economic democracy as it applies to the trade unions and to the employer or manager. Dr. Bryson insists, however, that economic democracy must have political democracy as its counterpart, and he suggests further that this conception of freedom will only be served when to these we have added what may be termed a democracy of culture, where creative genius will have its fullest scope to serve mankind. Just as he defines the conditions of freedom for the person as those that give full use to his creative powers, so he defines the free society as the creative society.

It is important to remember social science has external limits, as well as its internal imperfections. If we are to persuade men to make the effort involved in the scientific solution of human problems, we must, as Dr. Bryson rightly points out, not only meet the criticism that objective thinking has thus far done little to make human behaviour better by any rational standard, but also combat the widespread belief that science is wholly materialistic, deterministic and inhumane. In his succeeding chapters, and notably in that on education, Dr. Bryson gives some indication of his ideas as to how that is to be achieved.

The deeper habits of thought of the philosopher might well, as Dr. Bryson implies, have helped governments to avoid some of the disastrous mistakes of recent years if only by emphasizing the way in which, as each action is taken, the whole situation is more or less changed at the same time. He gives us a glimpse of the dangers of propaganda and of the possibilities in the right use of persuasion where freedom and personality are respected. In his final view of the good society, he once again insists on the necessity for the greatest possible diversity of institutions and chances for loyal attachment; and for the opportunity for the members of the good society to change their own individual patterns of loyalties, shifting from one institutional group to another not only at a time when the whole culture is changing but even with the idiosyncrasy of personal experience.

Whether or not we accept the whole of Dr. Bryson's argument, he has given as suggestive and stimulating

* The Governing of Men. By A. H. Leighton. Pp. xvi+404. (Princeton: Princeton University Press, 1945.)

a contribution to the whole question of freedom and order, of the relations between science and power, government and the individual, as Dr. Leighton has done in analysing his experiences in the re-location camp. They do not, it is true, take us a great deal further than Sir Ernest Barker did in his "Reflections on Government", though Dr. Leighton at least can quote evidence of the way in which a scientific approach has made a real contribution to the problem of governing men, and with the same success as attended the investigation at the Hawthorne Works of the Western Electric Company described by Dr. Elton Mayo and Dr. T. N. Whitehead. Dr. Bryson goes further towards providing the philosophical basis which Dr. Leighton equally recognizes as essential.

Most impressive of all, both books largely corroborate the truths which Sir Ernest Barker brought out and which more recently have been so brilliantly stated by Prof. R. M. MacIver in "The Web of Government"*. There is, indeed, grave peril when government usurps control over the myths of the community, especially since government is now armed with powers more formidable than it ever possessed before, against which democracy is the only safeguard; though, as MacIver points out, not an infallible safeguard, because people can be beguiled by propaganda along specious paths that lead to the end of democracy.

MacIver's lucid study displays two broad principles the full acceptance of which is essential if democracy is to endure. "One is that government should never be suffered to impose its controls on the cultural life of the community, to curtail the freedom of men to differ in their faiths and opinions, in their ways of thought and their ways of life, save when in the pursuit of these ways they inflict overt and objective demonstrable hurt on their fellow men. The second is a corollary of the first. It is that government should not be entrusted with so exclusive a monopoly over the economic utilitarian system that the implantation of these functions conveys with it the effective indirect domination of the cultural life. For if the life-chances, the very livelihood of individuals and groups are at the disposition of government, then the particular values and ideologies of the particular government will inevitably become absolute and will inflexibly impose themselves on the whole community, crushing its free spirit."

Some apprehension of this second precept may well be subconsciously behind the present concern of the medical profession in Britain over the National Health Service; but Prof. MacIver is right to hold that only by vigilant adherence to both these precepts can the peoples remain free and still breathe the life-giving air that comes beyond the realm of government. The relation between the advancement of science and political climate could scarcely be expressed better.

A recent forthright series of articles, "The Middle Class", appearing in *The Economist*, is also worthy of careful consideration. Under that title the position of the professional man is subjected to acute analysis, and there are many sound comments which the scientific worker in particular will appreciate. It was time that it was emphasized so bluntly that essential conditions of freedom for creative work in professional life are leisure, privacy, and the opportunity of external contacts: for high intellectual activity they are as essential as extra rations are to heavy manual labour. Sacrifice of such conditions is from the national point of view much the most serious consequence of the salaried classes losing ground out of all proportion to the general fall in national wealth, as compared with the wage-earner and the profit-maker; but it is a long way from being understood either by the Government or by many of the electorate. Neither is the civic, cultural or social *raison d'être* for the survival of the professional core of the middle class any more widely appreciated; and there are plain words indeed on the subject of experts without power in the third of these articles, which should be marked and heeded by every thoughtful and independent citizen.

It matters greatly how freedom and order are combined, and *The Economist* in this article points out that under present conditions the party system is giving us the worst of both worlds and that persistence in present tendencies in this era of social and economic engineering may have disastrous consequences. Both major political parties in Britain are hopelessly handicapped, and can be relied upon to paralyse their skilled administrators with political directives which frustrate purpose or nullify freedom. "So long as the professional class are merely instrumental in putting badly conceived plans into practice, their specific qualities will be wasted. And waste will continue until they are given a role in the framing as well as in the application of policy."

That is a challenge as well as a warning. National recovery and the large schemes of nationalization now being pressed forward in Britain will only succeed if we eliminate political bias and utilize to the full the principles and techniques of good management and sound administration. Self-interest, as well as his responsibilities as citizen, summon the scientific worker to play his part in establishing those conditions. For him this issue of freedom and order, on which the survival, not only of Britain but also of Western Europe, depends, is inseparable from the conditions for scientific advance; and the cultivation of intellectual freedom is itself a condition of the right and wise use of power.

* The Web of Government. By Prof. R. M. MacIver. Pp. 498. (New York: The Macmillan Co.; London: Macmillan and Co., Ltd., 1947.) 21s. net.

STORY OF HUMAN EVOLUTION

Mankind So Far

By Asst. Prof. William Howells. (American Museum of Natural History Science Series.) Pp. xii+319+7 plates. (London: Sigma Books, Ltd., 1947.) 16s. net.

THE ignorance of otherwise well-educated people concerning the origin of their own species is not a little astonishing, considering the personal nature of this problem and its intimate relation to philosophical concepts of human existence. One of the reasons for this apparent apathy, no doubt, is the

meagreness (until quite recently) of the direct evidence of the fossil record. Another is the difficulty which anthropologists so often seem to experience in making their field of study intelligible to the general public.

The first reason scarcely obtains any longer, for the discoveries of the last few years have filled in some of the gaps in the palæontological sequence in a most remarkable way. Now the second difficulty has been shown to be surmountable, for Dr. Howells, in his popular book "Mankind So Far", has not only adopted a style which is eminently readable (not to say entertaining), but has also managed to provide a great deal of important information without assuming any specialized knowledge on the part of the reader. His style is the conversational style of the accomplished popular lecturer, transferred directly into writing without any re-casting or re-phrasing to make it conform to the traditional method of presentation which is so commonly associated with the 'science manual'. The result is extraordinarily successful. For one thing, it makes the subject appear to the ordinary reader as exciting as it really is to the specialist. For another, it serves to emphasize that the science of human evolution (like other sciences) is nothing more than organised common sense and, as such, can be readily comprehended by the non-specialist. But it has yet another advantage. By reducing arguments which have from time to time been advanced for this or that partisan theory of human evolution from 'academic' phraseology to ordinary conversational style, the author has at the same time reduced them to their proper proportions, and sometimes, it must be confessed, has even shown them to be slightly ridiculous.

Dr. Howells' exposition of the study of human evolution is permeated by a robust common sense and by a welcome sense of humour which seems by no means out of place when he deals with controversies which, in more academic circles, have been conducted with unnecessary acrimony. We would particularly commend his illustrations, which are simple and direct and yet have obviously been carefully planned to clarify and emphasize his arguments with the maximum effect. They certainly achieve their purpose. The student who aspires to a mastery of human palæontology may be well advised to use this book as an introductory study.

MATHEMATICS IN INDIA

Ancient Indian Mathematics and Vedha

By Prof. L. V. Gurjar. Pp. vi+202. (Poona : Ideal Book Service, 1947.) 6.4 rupees ; 10*s*.

FOR too long the history of mathematics in India was studied only by scholars suffering under the almost insuperable handicap of belonging to an alien civilization ; but recently a number of Indian mathematicians have made a welcome appearance in this appropriate field. Prof. Gurjar's little book on mathematics up to the twelfth century and on pre-telescopic astronomical instruments is full of interesting material, but its tone is altogether deplorable.

European scholars began to study the mathematical classics of India a long time ago—Colebrooke's translation of the "Lilavati" was published in 1817—and no help from Indians was forthcoming ; the language was dead as well as foreign, the background had to be inferred, the idiom was enigmatical, and these pioneers made some of the mistakes which Prof. Gurjar would make if he attempted to translate "The Crafte of Nombrynge" or Chaucer's "Astrolabe" from imperfect contemporary manuscripts and was unable to find one Englishman competent to discuss his difficulties with him. Nor did the Europeans approach their task without taking for granted that the history of mathematics in India would fit into the story of mankind as they knew it : there was a road from Athens to Bologna and Paris and Oxford through Alexandria and Baghdad, and if mathematics was found to have been cultivated in medieval India, there must be another road from Greece to be traced.

Prof. Gurjar has still to learn to correct what he believes to be a mistake without jeering at it, and to challenge an assumption without resenting it as a deliberate insult to his people. To traduce scholars no less honest than himself is no way to impart a sense of confidence in his own interpretations of ancient texts. At the end of his account of Bhāskarācārya's work on indeterminate equations, he writes : "To deny the due credit and the honour to the Hindus, is a sheer obstinacy which only the prejudiced Western scholars are capable of having". But what, in fact, did Cajori, of whom Prof. Gurjar complains again and again, write in 1894 ? "The perversity of fate has willed it, that the equation . . . should now be called *Pell's* problem, while in recognition of Brahmin scholarship it ought to be called the 'Hindoo problem'. It is a problem that has exercised the highest faculties of some of our greatest modern analysts. By them the work of the Hindoos was done over again." And on another page : "It is remarkable to what extent Indian mathematics enters into the science of our time. Both the form and the spirit of the arithmetic and algebra of modern times are essentially Indian and not Grecian." This is the very language that Prof. Gurjar wants us to use. Cajori, it is pertinent to observe, is not an orientalist drawing conclusions from his own discoveries ; he is a historian reducing to the scale required for a comprehensive work the cumulative judgment of the actual investigators. Nevertheless, Prof. Gurjar roundly accuses the Western scholars, with the explicit exception of Hankel, of "hesitating to record the credit to the Indians simply because they are Indians".

A protest must be made. Burton was warning the British a century ago to be under no illusions as to the feelings of Indians towards them. The mathematicians of Britain bear as citizens their share of responsibility for their country's failures, but they can claim that as mathematicians they have consistently offered not patronage and generosity but appreciation and partnership ; the names of Mukhopadhyay and Paranjpye and Rajan, of Naraniengar and Prasad and Vaidianathaswami and a score of others, as well as the great name of Ramanujan, have been honoured equally at Cambridge and in their own land. Surely we have earned the right to expect from Indian mathematicians at this critical moment that whoever else prepares for the future in terms of hatred, they at least will proclaim the reality of interdependence, and the possibility of mutual respect and ultimate friendship. The nursing of grievances has perhaps caused more misery than any other uncivilized habit of mankind ; to add one untrue word to the tragic tale of past wrongs is wanton mischief, and to create a legend of injustice is an infamy.

E. H. NEVILLE

'PLASTHETICS'

The British International Plastics Annual, 1947
Pp. 274 + 183. (London: Croome Hill International, Ltd., 1947.) 63*s*.

THIS work is designed for that large body of users of plastics who require a central source of information on the varied aspects of the industry. It provides technical data on the materials available commercially, and practical advice on the machinery and technique in their treatment. For the present, the authors are only concerned with developments in the British Commonwealth and the United States, so that this volume bears the title "British International Plastics Annual". Later they visualize a true international plastics annual published in many countries and in many languages but identical in matter. A system of standardization is thus essential, and this is one of the objects the Annual sets out to achieve.

The book deals with all modern plastic materials, and these are laboratory-synthesized resins and plastic products from 'Acrylic to Zein'. The authors introduce the descriptive word '*Plasthetics*' (derived from *plastics*, *synthetics*) to cover these products.

An introduction to organic chemistry, colloids and analysis is followed by a general description of the main groups of plasthetics, which number about thirty types. The properties of synthetic plastics are treated under general, physical, mechanical, optical and electrical properties, the effect of chemicals and finally the standards of the American Society for Testing Materials. In the section on fabrication processes we find compression, transfer, jet and injection moulding, as well as the manufacture of laminates, foil and sheet. There is also a useful section on diathermic and infra-red heating. The miscellaneous applications of plastics are very varied, and include varnishes, lacquers, yarns, safety glass, printing and adhesives, also medical and biological uses.

A comprehensive directory section gives technical data on upwards of eight hundred British and American commercial grades of plastics, machinery and equipment, together with the characteristics of two hundred solvents and plasticizers. This section includes the societies, trade associations and educational facilities in the plastics industries.

A work of this kind in its first issue can scarcely hope to be free from blemishes, and the publishers provide a questionnaire asking for comments and constructive criticism. Certain criticisms are noted by the reviewer. The index is not adequate for finding the extensive information provided. Some organic formulæ require correction, for example, the breakdown of naphthalene (p. 20). The COOH and other groups are sometimes built into the aromatic ring (for example, in the phthalic acids, p. 114) when they are only substituents. The sensitization of colloidal gold by gelatine (p. 29) is rather out of place, and emphasis on its protective action would have been more to the point. Some of the formulæ for mechanical properties (pp. 144–153) require revision and correction, and the symbols should be those used in current practice by engineers.

Such criticisms, however, are of a minor character compared with the major qualities of this work. This Annual should be of great value to the members of the industrial world for whom it is intended. It is probable, however, that a wider range of readers will be eager to possess copies so far as the limited supplies will allow. The production of the book is of a high standard. Its useful contents, added to clear printing, good binding, and general appearance, will make it a worthy ambassador for British enterprise in the countries which it may ultimately reach.

S. R. CARTER

TEXTILE FIBRES

Matthews' Textile Fibers: their Physical, Microscopical and Chemical Properties
Fifth edition, prepared by a Staff of Specialists under the editorship of Herbert R. Mauersberger. Pp. xvi + 1133. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1947.) 75*s*. net.

THE conversion of fibrous materials into cloth or felt has commanded the attention of civilized man from earliest times, and over the years a great deal of skill in the manipulation of a wide variety of naturally occurring fibres has been acquired. The existence of subtle differences between the various grades of fibres is well established, and the selection and blending of raw materials plays an important part in successful commercial processing. Prior to 1904, when the first edition of "Matthews" was published, most of the information on textile fibres was an accumulation of the observations of inquiring growers and industrialists; but in more recent times scientifically trained chemists, physicists and biologists have been attracted by the many problems involved in elucidating the structure of fibres and in investigating their physical and chemical properties. Great advances in our knowledge of the basic characteristics of textile fibres have resulted from work of this type, and there are now sufficient data available to justify a chemical interpretation of the fine structure of most fibrous materials. Probably the greatest contribution of the scientific worker to textiles has been, however, the development of the rayon industry to a size comparable with that of industries concerned with the natural fibres. New rayons with extremely interesting manufacturing possibilities have been introduced, and the day is not far distant when fibres will be made to precise specifications laid down by users.

This great expansion of activity in the field of textiles, and the consequent spate of original contributions, created a need for an authoritative publication collecting together most of the existing knowledge, and this has been met by the new and fifth edition of "Matthews"—the result of a united effort by some forty-seven experts. The work has been carried out under the general direction of H. R. Mauersberger, who is a well-known editor of textile publications, and his collaborators include eminent specialists such as K. R. Fox, F. C. Atwood, P. Larose, R. F. Nickerson, E. R. Schwarz, W. A. Sisson, H. DeWitt Smith, and W. von Bergen.

Detailed accounts of the production and properties of both natural and man-made fibres are given, together with descriptions of lesser-known brush, cordage and fur fibres, and there are chapters on fibre testing and fibre identification. Although due emphasis is given to microscopical characteristics, physical and chemical properties, and research concerned with the study of fibre structure, the results of more technical investigations are not neglected. Thus data on the statistics of fibre production and

details of the characteristics of the many commercial grades of each type of fibre are included. It is perhaps inevitable that stress is laid on American research and practice, although reference is made to many British papers.

The book is extremely well written and presented; the illustrations are good, the printing very clear, and the binding and quality of paper are such as to make most English authors envious. All who are interested in textiles, whether they are research workers, manufacturers, salesmen, directors, teachers or students should find this volume particularly valuable, for it is probably the most important publication on textiles which has appeared in the last twenty years. The authors are to be congratulated on their achievement. C. S. WHEWELL

ELECTRONICS IN INDUSTRY

Electronics for Industry

By W. I. Bendz, with the assistance of C. A. Scarlott. Pp. x+501. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1947.) 5 dollars.

THE purpose of this book is to introduce the engineer who has had no special training in electronics to the fundamental principles involved in them, and the means of their practical application. The latter include a very wide range: photo-electric devices, high-power rectifiers, high-frequency heating, and various types of control circuits. The diagrams are mostly basic circuits illustrating the methods used, and so are not confused by minor details, though some actual circuits are given.

On the theoretical side, the book opens with a very clear introduction to as much of modern atomic physics as is necessary for the understanding of the action of practical electronic devices; this is material on which the average engineer is often sadly deficient.

The characteristics of the various types of valves are then dealt with, particular attention being given to the form of discharge in gas-filled valves, and there are many illustrations of actual electrode systems. The nomenclature throughout is the American standard, which differs from that in use in Britain; but the meaning of each expression is fully defined. Attention is then given to rectifiers of all types, from the small power pack for ordinary valve circuits up to the high-power three-phase mercury vapour type, with constructional details of the latter. Considerable attention is given to various types of firing circuits; but distortion of wave form is only slightly dealt with. In the chapter on amplification the basic principles are clearly dealt with, the work being entirely confined to medium-frequency working, no reference being made to the special difficulties which arise with high- and ultra-high-frequency working. A chapter on oscillators follows, all the normal circuits including dynatron and beat-frequency circuits being given, as well as a short description of the piezo-electric crystal.

After a short chapter on modulated signals, the rest of the book is given up to the description (including circuit diagrams) of all types of commercial electronic applications, classified under various headings: and this part contains much information which, up to the present, has been difficult to get in collected form without reference to specialized papers.

Taken as a whole, the book should be of great value to the user of electronic devices; it is not intended for those who have to design them, though throughout there are many references to more detailed information, including a bibliography at the end of each chapter. J. HOLLINGWORTH

ATOMS FOR THE LAYMAN

The Atom and its Energy

By Prof. E. N. da C. Andrade. Pp. xii+196+12 plates. (London: G. Bell and Sons, Ltd., 1947.) 10*s*. net.

Meet the Atoms

A Popular Guide to Modern Physics. By O. R. Frisch. Pp. xiv+226. (London: Sigma Books, Ltd., 1947.) 12*s*. 6*d*. net.

PROF. ANDRADE is an old hand at explaining the mysteries of atomic structure; his "Structure of the Atom" was the standard text in the days when electrons circulated on nicely calculable orbits around the nuclei that Nature provided for our study. The electrons have long since abandoned their tramway-like orbits and, like buses in a fog, have a mere probability of being somewhere near a given route; new kinds of nuclei can be manufactured at will in great variety; and we have learned how to use, or misuse, the immense energy of nuclear forces.

In "The Atom and its Energy", Prof. Andrade marshals the modern array of atomic facts and theories with his usual skill, illuminates them by ingenious analogies, and spices the dish with a literary flavour; though the reviewer's metaphors may be mixed, the author's are not, and they magnify the atoms to visible size with amazingly little distortion.

Prof. Frisch, in "Meet the Atoms", follows the more informal plan of taking the reader into the laboratory and explaining how experiments in nuclear physics are devised, performed and interpreted. The apparatus is there, real and life-sized, and there is no need to magnify it; but when an analogy can help in interpreting the observations, Prof. Frisch does not hesitate. For example, he compares the dual wave and particle aspects of light to the appearance of an animal that everyone's right eye sees as a dog and everyone's left eye sees as a cat; he remarks that in time we would get used to this and would cease to worry about which it 'really was'. Such analogies, crude though they may be, are in harmony with the atmosphere of a real laboratory, where the apparatus and the conversation are not always highly polished. Prof. Andrade's book belongs rather more to the study, and has both gained and lost by its slight detachment from laboratory details.

The cat-and-dog analogy does not apply to this pair of books; each author sees the atoms clearly with both eyes, and explains them to the reader in his own way. The books are not, of course, written for the expert, but they will hold the interest of physicists as well as of the less-specialized public for whom they are intended. They are books about atoms and not primarily about atomic energy; Prof. Frisch deliberately says very little about that subject, and Prof. Andrade is not at his best when dealing with its technical and scientific aspects, though his comments on the moral and political issues show the clear thinking and fine writing that we expect from him. P. B. MOON

Microdiffusion Analysis and Volumetric Error

By Prof. Edward J. Conway. Revised edition. Pp. xix+357. (London: Crosby Lockwood and Son, Ltd., 1947.) 21*s*. net.

MICRO-DIFFUSION analysis represents a real advance in modern analytical technique. It seems strange, in fact, that the underlying principle of allowing the gaseous product of a reaction to diffuse, in a closed chamber, into a suitable absorbent or reactant should not have been used more extensively in analytical procedures at a much earlier date. Absorption of gases into appropriate reactants by distillation and aeration methods is, of course, the basis of many well-known, and important, chemical and biochemical methods of analysis, but the methods are usually tedious and extravagant in apparatus and material. Conway's technique involves the use of a simple and inexpensive glass apparatus (termed the 'Unit') consisting of an inner and outer chamber. The gaseous product of a reaction (for example, ammonia, volatile amines, carbon dioxide, acetaldehyde) passes from one chamber, where the gas exerts a certain tension, into an absorbent in the second chamber, where the tension approaches zero. Analyses are made of the contents of the second chamber, and the accuracy is limited only by the accuracy of delivering and titrating fluid volumes of the order of 1 ml. Conway claims that the method appears to be the "simplest possible consistent with the maximum attainable accuracy in the handling of micro-volumes". The technique has been adopted for analyses of ammonia, amides and amines, adenosine and adenosine derivatives, halogens, alcohol, acetone, lactic acid and glucose, carbon monoxide and carbon dioxide. It may be used also in the estimations of enzyme activities.

Conway's book describes his 'Unit', the various physico-chemical factors involved in diffusion techniques, the micro-pipettes and burettes required and the errors involved in their use. It gives details of the analytical methods involving the micro-diffusion technique which have now been adopted in many laboratories, and it has a most valuable section on the errors encountered in volumetric titrations. It has a good bibliography, and is well illustrated and produced. It is a book which should be in the hands of most biochemists and clinicians.

Archæology and Society

By Grahame Clark. Second edition, revised. Pp. xv+222+24 plates. (London: Methuen and Co., Ltd., 1947.) 10*s*. 6*d*. net.

THIS is a welcome new edition of a book which in October 1939 found a rapid sale, and should certainly do so now. It is one of the best and most readable short introductions to archæology in general, and though much in it has needed no revision, Dr. Clark has related his themes to their present-day setting with sound judgment. Archæology studies how men lived in the past: in partnership with documentary history if available, but in any event with confidence that it can do much that its partner cannot, in particular, of course, in the study of prehistoric times. This does not make it in itself altogether a science; yet it owes its modern precision largely to its growing capacity to collaborate with natural sciences, in the application of their techniques to the study of man's past doings. In that matter Dr. Clark at Cambridge has himself long been a leader, and this gives especial value here to his chapters on archæological discovery, preservation, excavation and chronology. Finally, too, he gives us some excellent plain speaking on the all-important 'social relations' of his subject: research must be kept free of perversion by nationalism, and devoted to the honest pursuit of historical truth.

C. F. C. HAWKES

Faraday's Encyclopedia of Hydrocarbon Compounds

(Covering the Literature up to January 1st, 1947). Compiled by Dr. Joseph Escott Faraday. Vol. 4: C_9. Pp. lxxxviii+448. (Manchester: Chemindex, Ltd., 1947.) £5 10*s*.

DR. FARADAY, in accord with his promise, now presents us with volume 4 of his encyclopædia of hydrocarbons; the author and his publishers are to be heartily commended on being able to keep such a promise in these difficult times. The present volume deals with the C_9 compounds up to January 1, 1947, and follows closely the lines of the previous parts, now so well known to organic chemists.

It is stated in the foreword that future volumes will contain the Dyson cipher of the compounds described: this will greatly increase the value of the work if and when the Dyson cipher becomes widely used.

It came as a slight surprise to the reviewer to find indane called 1:2-trimethylane-benzene, and indene, 1:2-trimethylene-(7)-benzene; on reflexion, this possibly appears logical, but it will surely be some time before 1:3-tribromopropane is called trimethylane dibromide, and surely the group $>CH_2$ is methylene, although perhaps this term should be reserved for $=CH_2$. Hydrindane, which might be expected to be 1:2-trimethylane-*cyclo*hexane, is bicyclo-hexane-(1,2)-pentane.

The reviewer is, of course, well aware of the difficulties of systematic nomenclature, and the above remarks cannot be taken as adverse criticism.

The Yearbook of the Universities of the Empire, 1947

Published for the Universities Bureau of the British Empire. Pp. xxxi+1098. (London: G. Bell and Sons, Ltd., 1947.) 21*s*. net.

THE usefulness of this valuable reference book is attested by the sorry condition to which the last issue, that dated 1940, must have been reduced in any institution or department in touch with university affairs. The war-time Supplement issued in 1941 carried on the information for but a short space, and it has been necessary to wait six years before the complete data relating to the staffs of the universities of the British Empire could be made available once more. Even now, due to the rapid expansion taking place in the universities themselves, and also to the longer time now required for printing such a book, it is not claimed that the information is up to date in the sense it used to be. The new volume contains about a hundred pages more than that for 1940—an indication of the growth of the universities that has taken place.

As before, the information under each university includes a directory of the officers and staff, general information and reports of events of outstanding interest during the previous year. There are appendixes on the qualifications for admission to a first degree, statistics of foreign students in British universities, general conditions in American universities, and Anglo-American professorships.

OPERATIONAL RESEARCH IN THE RESEARCH ASSOCIATIONS

WHAT is 'operational research'? Is it an activity of major importance to industry? Can it be carried out effectively by co-operative organisations such as research associations? How does one set about organising operational research? These questions were examined at a conference on January 13 and 14 attended by representatives of most of the research associations and of a number of establishments of the Department of Scientific and Industrial Research. The conference was organised by the Committee of Directors of Research Associations under the chairmanship of Mr. B. H. Wilsdon, and was held at Ashorne Hill, through the courtesy of the British Iron and Steel Federation. The conference showed that it was possible to make a reasonably clear definition of the subject, and that operational research in one form or another had proceeded with growing emphasis in certain of the research associations very successfully for a considerable number of years. The research associations generally find themselves very suitably placed for an extension of this type of activity, in view of the wideness of the fields they survey and the close contacts they have with the executives in the industries they serve.

It was desirable to obtain first a general form of words and then to follow this by a consideration of the various factors that make up what might be called 'Operational Research'. The discussion was opened by Sir Charles Goodeve, who proposed a definition based on that put forward originally by Dr. Charles Kittel[1]. After some discussion, the following amended form was considered accurate enough for most purposes:

Operational Research is the use of the *scientific method* in providing executive departments with a *quantitative basis for decisions* regarding the *operations* under their control.

The most problematical part of the definition was in the scope associated with the word 'operations'. In general, it was considered desirable to keep this scope as wide as possible, ranging from the operations in ordinary production engineering to policy matters associated with consumer needs, national economic positions, etc. The chief difficulty appeared to be in drawing a line between process or equipment research and operational research, and it was clear that any attempt to draw a sharp line would be artificial and probably harmful. The difference between 'process' and 'operational' research comes down largely to one of direction of approach. The operational research worker starts with the overall picture and may study individual processes in relation to the whole picture, whereas the process research worker is more concerned with developing certain processes to the highest pitch of efficiency in relation to other parallel or following processes. In addition, there is a difference in degree in that the operational research worker more often has to rely on observations of happenings over which he has no control, whereas the process research worker can generally carry out deliberate experiments with at least a substantial degree of physical control. The operational research worker much more frequently has to deal with human factors, market conditions and the many other factors troubling men in executive positions.

Dr. F. C. Toy, director of the British Cotton Industry Research Association, which organisation has undoubtedly been among the pioneers in this type of work, opened the second session of the conference. He said that, judging by his own experience, operational research should form an integral part of the activities of a research association. It can obtain a comprehensive picture for the whole industry by a collection of data from individual firms, which can be summarized by a statistical digest and a general report. By feeding back this digest to all firms, together with a special confidential report to each individual firm, the executives concerned can see their own position in the light of a complete and accurate background. These reports often act simply by stimulating managers to look again at problems or deficiencies already known to exist. This method has proved to be a much quicker way of improving efficiency than the old one of waiting for economic factors to bring into successful prominence the more efficient plants. These studies can also bring out quantitative information on the factors affecting an industry as a whole, and thus aid in determining the right policies for the industry. This is an especially important point in these days when the Government has to deal with many contending issues.

Dr. Toy discussed the prospects of operational research being carried out by organisations other than research associations. Individual firms and professional industrial consultants are limited to studies inside the confine of a particular works; but they can obviously be helped by the wider picture provided by the research associations. The universities and technical colleges are unsuitable for this type of work, but they play a major part in training personnel. The trade federations have a wide picture of the commercial side of each industry; but their lack of technical knowledge and of scientific atmosphere puts a severe limitation on their activities. However, research associations should work in closely with the trade federations, since many of the executive decisions have to be made by such bodies. There may be special instances where operational research should be carried out in industry by Government teams; but if this is done widely in industries served by research associations, it means duplication of effort. In addition, managements are more ready to co-operate with people in an organisation belonging to their own industry than with those who may be looked upon as Government investigators.

All these arguments supported Dr. Toy's contention that, because of the scientific atmosphere, complete impartiality, close contact with industry, with other research organisations and with Government departments, and because of the confidence placed in them by management and operatives, the research associations are the most suitable bodies to carry out operational research in industry.

Mr. A. T. Green, director of the British Ceramics Research Association, pointed out that operational research methods are of particular value in the older industries where the processes are based on traditional methods developed by subsequent experience. He referred to the detailed works surveys carried out for the National Brick Advisory Council. These give valuable indications of the labour used and of the minimum requirements under a wide variety of manufacturing conditions.

Dr. S. Whitehead, director of the British Electrical and Allied Industries Research Association, spoke about operational research in fields ranging from high-power transmission to radio interference, and emphasized that operational studies frequently pro-

vide certain links in a chain of deduction of which the remainder are supplied by science and engineering.

Mr. H. Bradley, director of the British Boot, Shoe and Allied Trades Research Association, described the extensive surveys made into the fittings of shoes, based on analyses of measurements of some thousands of feet. For example, most factory-made women's shoes are produced in what are known as single-fitting ranges, that is, each size or half-size of length is made in only one girth. It has always been the practice in the industry to add $\frac{1}{4}$ in. in girth for each successive size. How this interval was arrived at nobody knows, and the analyses of foot measurements showed the correct interval to be 3/20 in.; or 40 per cent less. The practical effect of this on the fitting properties of shoes, particularly the extreme sizes, is considerable, and the Research Association's 'precision grading' based on the new girth interval is having great commercial success.

Mr. D. J. Bishop, of the British Iron and Steel Research Association, showed how a large part of the research programme of that Research Association is continually under study by the operational research team with the object of providing those concerned with the framing of that programme with adequate information, so that research can be focused on problems the solution of which is likely to produce the greatest economic advantage to the steel industry. This is a case where operational research is used at a 'strategic level' to guide research policy.

It was clear from the points raised by numerous speakers that, despite the large volume of operational research already proceeding in industry in Great Britain, many obstacles would have to be overcome before the desired wide application could be attained. In some industries, the firms' problems are so diverse that wide approaches or comparisons are of little value. Also, some industries have been built up and owe their strength to keen competition between firms. Mr. Wilsdon pointed out that, in operational research *within* an industry, it is essential to take into account variation in the quality of the product, which must be associated in some way with the expenditure of energy in the operations studied in order to provide a comparable basis for executive decisions. Thus criteria such as operations per man-hour or the like might be positively dangerous unless there are good grounds for assuming that the quality of the product is the same throughout. It is clear, therefore, that different industries are likely to adopt operational research to different extents.

On the other hand, as was pointed out by various speakers, there never has been a more favourable opportunity for an extension of operational research. With the present 'sellers' market', competition is at a minimum and co-operation at a maximum. Organised labour, which has always had to look first for security of employment, is able now to take a broader view and consider efficiency of employment.

The discussion on organisation and staff was opened by Mr. Tippett, of the British Cotton Industry Research Association. He considered that a separate operational research team is desirable if the subject is to be treated with the seriousness and comprehensiveness its importance requires. The separate team requires close contact with the management side of industry, with the trade associations, Government departments, etc., and also should have close contact with the field observational work. The team should be staffed with men chosen first of all for their ability to view things widely. They should have good scientific ability, and need to acquire technical knowledge of the industry they serve; but they need not have any particular specialized qualifications. The knowledge of statistics required for most of the work is not very great, although it is desirable to have at least one first-class statistician in a team. It is very important that members of the operational research team should be able to talk to managers, foremen and operators, and to get on well with everyone in the factory.

The objects of operational research which have been or could be carried out by the research associations can be summarized as follows: (1) to increase production per man hour, per unit of equipment, or per unit of fuel; (2) to improve quality and suitability of products; (3) to improve the basis for decisions regarding the application of science ('bridging the gap'); (4) to make accurate studies of consumer or market problems, that is, scientific studies in market research; (5) to aid in finding the optimum degree of standardization for any particular field of production; (6) to aid in the planning of research programmes.

The proceedings concluded by short talks by Dr. W. L. Francis, of the Department of Scientific and Industrial Research, and Dr. Alexander King, director of the scientific secretariat, Lord President's Office, on operational research activity and interest in Government departments. C. F. G.

[1] Kittel, C., *Science*, **105** (Feb. 7, 1947). See also Goodeve, C. F., *Nature*, March 13, 1948, p. 377, for general article on operational research.

FOOD PRODUCTION FROM HILL GRAZING LAND

By Dr. GEORGE DUNLOP
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THE Minister of Agriculture has pointed out that while before the War, for Great Britain as a whole, less than 40 per cent of our food, on a calorie basis, was produced at home, this figure in 1946 had increased to almost 70 per cent.

The land of Scotland may be classified under the headings of:

(1) Farm land: arable and grass land.
(2) Hill pasture.
(3) Other land: deer forests, woodlands, etc.

Sir John Russell has estimated that one acre of farmland produces sufficient food for one person. The population of Scotland is about five million and the arable and grassland acreage about the same figure. This indicates that Scotland is self-supporting in food. It is true that tropical foods, such as grapefruit, bananas, etc., are imported; but on the other hand a good proportion of the arable acreage is devoted to the production of seed potatoes which are transported to England and abroad. Similarly, surplus milk on occasion has found a market south of the border.

The agricultural returns show that there are approximately ten million acres of hill land in Scotland devoted to hill sheep farming. The agricultural production of this type of land will be discussed later. The remaining four million acres may be classed, so far as agricultural production is concerned, as 'waste',

and consists mostly of deer forests and woodlands, from which the agricultural productivity is practically nil.

The hill sheep grazings, which are found on more than half of the land of Scotland, produce, according to the Hill Sheep Farming Report[1], 1·4 million draft ewes and lambs which are sold in the autumn of each year. Most of these animals have to be fattened on arable pasture. Responsible livestock graders of the Ministry of Food estimate that the overall average carcase weight of these animals when drafted from the hill grazings is 30 lb. It is clear, therefore, that the hill grazings of Scotland produce 42 million lb. of mutton and 10 million lb. of wool on the average per year. For the five million people in the country, that half of Scotland devoted to sheep farming on hill grazings provides the equivalent of only four days supply of calories and protein yearly.

With the increasing urge for greater home production the question arises as to how the productivity of the hill grazings may be increased. At present given over to hill sheep farming, they are stocked almost solely by hill sheep. The basis of this system is the reduction of the stocking of the hills to the number of animals which the grazings can support during the winter months. The Hill Sheep Farming Report gives the number of ewes carried under these conditions as only 2¼ million on the 10 million acres of hill grazing.

The secretary of the National Sheep Breeders' Association has stated that seventy years ago there was a total of 30 million sheep in Great Britain as a whole, which number decreased continuously until 1920. In 1920 after the First World War there were only 20 million sheep in Britain. This figure increased up to 1940, when the number reached about 26 million, but after 1945–46 only 19 million remained. In 1947, largely as a result of the severe winter, the figure has dropped to a record low level of 16 million. "At no time in our history have we ever needed an increase in the supply of good British meat as we do now."

It appears unlikely that the 2¼ million breeding ewes at present carried on the hill grazings could be greatly increased under the hill sheep farming system even if the stocking was stepped up to what it was seventy years ago. It would scarcely double itself and it would appear, therefore, that any great increase of food production from grazings devoted to hill sheep farming should not be looked for.

The truth is that the productivity of the hill grazings is not reflected by the number of sheep sold each autumn. The sheep consume only a small part of the herbage produced on the grazings. Most of it is consumed by a fire which sweeps over the grazing every other spring-time. The herbage should be eaten off by animals and not burned off if productivity is to increase.

Research work has shown the inadvisability of grazing herbage constantly with one species of livestock. The internal and external parasites of the host animals increase in numbers until they become a serious menace. Many of the stock may actually die after years of decreased productivity on the grazing.

Furthermore, the amount of herbage produced per annum is greatly reduced owing to the constant grazing of the animals. Stocked as they have been for centuries to their full carrying capacity during the winter months, the spring flush of herbage, although still marked, has been greatly checked by the hard grazing in winter. Cattle are the species of livestock of choice which must return to the hills in much greater numbers than ever before. It is suggested that the hill land of Scotland be devoted principally to beef production or to dairying.

With the increase of home food production since the outbreak of the War, five herds of beef cattle of about a hundred breeding cows each have now been maintained throughout the year on grazings in West Perthshire since 1939. Although the acreage of grazing allotted to these animals is more than might be desired if maximum food production is the aim, it is interesting to note that the sheep stock has not decreased as many farmers appeared to expect, but has actually increased since the cattle were introduced. The animals remain on the hill all the year round but receive some fodder—straw or hay—from January until April. During this period the amount of herbage which is available on the grazing is very limited and the animals would probably fare much better if fed indoors. Their loss of condition during the early months of the year does not, however, appear to affect the calving percentage of the herd, which is the chief consideration. The progeny are taken off the hills in the autumn for fattening off on low ground.

The hill sheep farming system as practised at present on some of the grazings has been traced back to medieval times, when the chief consideration of the monks was wool production per abbey[2] and not maximum food production per acre. The whole object of 'hill farming' has changed in the interval.

After the 1947 experiences on hill grazings, it would appear that even the sheep stocks should be removed to lower ground from January and fed from the flush of herbage of the previous summer preserved either as hay, silage or dried grass. *All* grazings on hill land would benefit by at least two months rest in late February, March and April. It has been shown by Edinburgh parasitologists that large numbers of worm larvæ are picked up on the hill at this time and the mature worm burden rises to its maximum during June. It would appear that the food for the hill stock during the early months of the year should consist mainly of silage, hay or dried grass gathered from the previous summer flush of herbage on enclosed hill land. Recent experiences in Argyllshire and West Perthshire show that dairying can be conducted successfully on hill grazings, while the outdoor bail system has also proved successful in Morayshire and Fife. Ernest attempts should be made to extend the milk production of the country to hill land. A price incentive would be required and it is suggested that, after industry can supply all the equipment such as milking bails, material for covered courts, fencing, etc., dairying on arable land in Scotland should be discouraged and hill dairying encouraged by price regulation, say, 1*s*. 6*d*. per gallon for milk produced on arable land and 2*s*. 6*d*. per gallon for milk produced on hill land.

Such an enterprise, largely on hill land in West Perthshire, not only provided for the requirements of four local village communities but also exported milk to the industrial areas. On the other hand, Highland communities in proximity to which no dairying is practised obtain their milk supply from the arable and dairying areas of the Lowlands or from Ireland during the winter months. 'Milk from the Mountains'—the motto on the milk bottles of the Perthshire pioneers—would appear to be the policy for the hill grazings.

It was recommended by the Departmental Committee, appointed by the Secretary for Scotland in 1909, in its report on livestock and agriculture in the congested districts of the Highlands[3] that, where considered advisable, assistance be given in changing the cattle to a dairy breed. "Some districts appeared suitable for dairying—and dairying would pay infinitely better than their present system." "In many districts there was a dearth of milk during the winter and the children suffered therefrom."

Instead of the 4 lb. of mutton per acre which at present the hill grazings produce, we could have 50 lb. of beef or 50 gallons of milk; these latter standards are at present being attained on hill land. It is suggested that *in addition* 10 lb. of mutton per acre might be produced if hill grazings of Scotland were properly farmed instead of being ranched as they are at present.

[1] Report of the Committee on Hill Sheep Farming in Scotland (H.M. Stationery Office, 1944).

[2] Fraser, Allan H. H., "Economic Aspects of the Scottish Sheep Industry", *Trans. Highland and Agric. Soc. Scotland* (5th Series), 51, 39 (1939).

[3] Report of the Departmental Committee on Livestock and Agriculture in the Congested Districts in Scotland (Cmd. 5457) (H.M. Stationery Office, 1910).

THE STATUS OF THE PROTOZOA*

By Dr. JOHN R. BAKER

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II

Death in Protozoa and Metazoa

IT has been said by opponents of the cell-theory that since a single protozoon corresponds with a whole metazoon and not with a single cell, one might expect to find in Protozoa something corresponding to somatic death; and this is supposed to be represented by the degeneration of the macronucleus in Ciliophora and by comparable processes in certain Sporozoa[14]. It is necessary to consider the significance of this degeneration. The macronucleus of Ciliophora, as we have seen, must be assumed to contain the same gene-complex as the micronucleus, in polyploid form. But the degeneration of the macronucleus is particularly prone to occur precisely when the gene-complex of the micronucleus is changed, whether by conjugation or endomixis. The macronucleus is then replaced by a new one, containing the new gene-complex, presumably in highly polyploid form. Now it is supposed that the significance of conjugation and of endomixis is the origin of a new gene-complex. The necessary result of the degeneration is that the individual ciliate does not possess both the old and the new gene-complex, but *only the new*. If the old macronucleus were retained, it would swamp the effects of the new gene-complex, possessed by the reconstituted micronucleus. This, then, is surely the significance of the degeneration of the old macronucleus.

There is nothing that corresponds exactly to this process in Metazoa; but the degeneration of the chromatin in polar bodies is functionally similar, for if the genes contained in these bodies were retained in the egg, the old (diploid) gene-complex of the mother would co-exist, after fertilization, with the new (haploid) one brought in by the spermatozoon. One may, if one chooses, draw a rough comparison between the degeneration of the macronucleus and that of the chromatin of polar bodies; but there is neither homology nor functional correspondence with the death of a metazoon. In death there is decay of the whole of the protoplasm, not of the chromatin only; and in the ciliates the chromatin of the macronucleus does not appear even to be excreted. Roskin[15] has shown that the macronucleus of *Paramecium* may contain a considerable amount of ribose-nucleic acid, and it seems that at 'degeneration' there is a distribution of this substance throughout the organism. The most likely hypothesis is that 'degeneration' involves conversion of desoxyribose-nucleic acid into ribose-nucleic acid, with break-up of the chains of genes. There is evidence from Metazoa that desoxyribose- and ribose-nucleic acids are interconvertible, and it is likely that the ribose-nucleic acid dispersed through the body after degeneration may be built up into the 'chromatin' of the new macronucleus. This matter urgently requires investigation. There is nothing resembling death in the changes that are known to occur in the degeneration and reformation of the macronucleus. Death is a familiar process in the Protozoa, despite their potential immortality; and when it occurs, it shows no resemblance to degeneration of the macronucleus.

A Comparison between the Cleavage of Eggs and the Division of Protozoa

Those who deny that a protozoon can ever be regarded as a cell lay stress on a supposed difference between cleavage of an egg on one hand and the multiplication of a protozoon by division on the other. It is suggested that while the cleavage furrows are dividing the egg, the latter is being passively partitioned and the blastomeres are not increasing in volume, while in the Protozoa there is no mere partitioning by furrows, but a regular alternation between phases of division and phases of growth and differentiation. Actually it is doubtful whether any hard and fast distinction can be drawn between the two processes. When a protozoon is multiplying rapidly, the size becomes reduced. When division occurs within a cyst or firm cell-wall, for example, in *Chlamydomonas*, the size of the products of division is reduced just as in cleavage. To speak teleologically, the cleaving egg has generally no reason to grow, because sufficient food-substances have already been stored up inside it to last until a multicellular food-gathering apparatus has been formed. In some cases, however, the reserve food to be used by the embryo is external to the egg, and in such cases the blastomeres do grow, and may separate from one another in so doing and become irregular in form. This has been known for a long time. Growth of blastomeres was remarked by van Beneden[16] in the cleavage of *Tænia serrata*. The phenomenon is particularly clearly exhibited by some of the Turbellaria. For example, Hallez[17] found that if the volume of the egg of *Paravortex cardii* be taken as unity, that of the two-cell stage must be represented by 1·33 and that of the blastomeres of the four-cell stage by 5. In other words, each blastomere is now larger than the egg was: there has been even more growth than would have been characteristic of a protozoon. A similar state of affairs, though with less growth, is seen in the cleavage of the summer eggs of another rhabdocœl, *Bothromesostomum personatum*[18]. The most striking example of all is provided by the triclad, *Dendrocœlum lacteum*, for here the blastomeres are irregular in shape and lie quite

* Continued from p. 551.

separately from one another in a fluid derived from the yolk-syncytium; and they grow between one division and the next, so that the total volume is greater at the later stages of cleavage[19]. Since the blastomeres increase in size, are separate, and do not maintain a spherical shape, their resemblance to Protozoa is striking. There are, in fact, all gradations between *cleavage by partitioning* on one hand and an *alternation between phases of growth and of division* on the other; and all these gradations occur *both in Protozoa and in Metazoa*. No valid distinction between cells and not-cells can be drawn on the basis of differences of this sort.

Evolution of Metazoa from Protozoa

These considerations may be applied also to the evolution of Metazoa from simpler forms. There are those who consider that Metazoa originated by the failure of Protozoa to separate after division, while others insist that the many-celled condition arose by the appearance of partitions in a protozoon, and that until these partitions were formed, there was no such thing as a cell. Since there is no palæontological evidence and no one has ever seen a metazoon originate in evolution, this is not a matter on which certainty can be reached; but, as we have just seen, some Metazoa certainly originate in ontogeny in one way and some in the other, while others show an intermediate condition; and this shows that the two extremes are not alternatives, but the end-points of a series.

Dobell[20] has written, "The succession of individuals formed from one conjugation to the next is not comparable with a metazoan body any more than a swarm of bees is comparable with an elephant", and again, ". . . it is clear that a protist is no more homologous with one cell in a metazoon than it is homologous with one organ (for example, the brain or liver) of the latter". One must agree that a single elephant does not correspond with a swarm of bees: only a herd of elephants would be at all comparable. But the argument suggests that it is unthinkable that individuals should associate together to form an organism exhibiting a new grade of individuality. It is clear that bees could not do so, because their firm, chitinous external surface does not lend itself to the adhesion of one individual to another, and their organisation is such that they would be seriously incommoded in their activities by such adhesion; this kind of association is only to be expected in more plastic forms and in groups that possess the faculty of asexual reproduction. In such groups the association of individuals of one grade to form an individual of a higher does, of course, occur. Integration of this kind probably reaches its climax in *Pennatula*. No one who is familiar with the anatomy of this animal can doubt that each constituent polyp is comparable to a single *Haimea* or *Hartea* (or, to take a more familiar but less closely related form, *Hydra*). Yet the polyps of *Pennatula* are differentiated in structure in relation to their separate functions, their activities are integrated together, and the whole compound organism has even taken on a marked bilateral symmetry.

Now it would clearly be wrong to compare a single *Haimea* with a whole pinna of *Pennatula*, which consists of many polyps. This would be like comparing a single protist with the brain or liver of a metazoon. But there is no more absurdity in comparing a unicellular protist with a single cell of a metazoon than in comparing a single *Haimea* with a single polyp of *Pennatula*. Error could only arise if one were to choose a non-cellular protist, such as a radiolarian or ciliate, when making the comparison.

There has been some tendency for two separate questions to be confused. One may ask: 'Did Metazoa originate by the adherence of Protozoa after division?' To this no certain answer can be given, because no observations bearing directly on the point have ever been made. One may also ask: 'Is it logically conceivable that Metazoa originated by the adherence of Protozoa after division?' There can be only one valid answer to the second question, and that answer is 'Yes'. The suggestions to the contrary that may be found in the literature are not backed by evidence.

It may be remarked that while such forms as *Volvox* raise a storm of controversy among zoologists, they are not regarded as unusual by botanists, who are familiar with such colonial forms in groups other than the phytomonads. Botanists regard them as composed of cells, which are comparable on one hand with the individuals of what they call unicellular species, and on the other with the cells of higher but related forms, in which there is somatic differentiation (heterotrichous forms and other algal metaphytes).

If we seek the reason why zoologists are more divided in this controversy than botanists, we shall surely find it in a fundamental difference between plants and animals. In the lower plants *each group* tends to present both unicellular and metaphytic representatives, and botanists are repeatedly confronted with the intermediate forms. Metaphytes, in fact, have obviously originated independently many times, so that no one would propose the word 'Metaphyta' in any classification that was supposed to be based on evolutionary principles. With animals it is far different. Zoologists have not got intermediates again and again before their eyes. In the great group of Rhizopods, for example, there is no example of a multicellular form (the word 'cell' being here used as defined on p. 549). It would not appear that anyone has discussed the reason for this striking difference between plants and animals. The following suggestion may be made. The unicellular plant absorbs nutriment from all sides equally, and when, in the course of ontogeny or phylogeny, it becomes a metaphyte, there is no fundamental change in this respect: a cell divides without separation and the two products continue to absorb nutriment over most of their surfaces. The passage from the unicellular form to the metaphyte is therefore easy. In the case of animals, however, there is an important change when a unicellular form becomes a metazoon: a *new method* of feeding must be adopted. We see this particularly clearly in the ontogeny of *Dendrocœlum*. The blastomeres feed at first saprozoically, but at last a profound change occurs: a set of digestive organs originates, and a new method of nutrition begins. Most animals overcome this difficulty in ontogeny by placing enough reserve foodstuffs within the single-celled stage to make feeding unnecessary. It is easy to see what evolutionary difficulties must be presented when a *new system* of nutrition must be acquired before advance can occur. The difficulties would be greatest when a protozoon had a localized mouth. If the products of division of such an animal were to adhere together and each were to acquire its own mouth, no advance would be made towards the evolution of a metazoan alimentary canal. This suggests that the Metazoa may have arisen from primitive Protozoa, unprovided with localized organs of assimilation. These considerations

seem to make it clear why intermediates between unicellular animals and Metazoa are rare, while intermediates between unicellular plants and metaphytes are common. (The colonial phytomonads are, of course, only regarded as animals by zoologists on account of their motility: their nutrition, it need scarcely be said, is holophytic or saprophytic.)

I acknowledge the help given by many friends in the course of conversation. In particular, I must thank Prof. A. C. Hardy, Dr. S. M. Manton and Dr. C. F. A. Pantin for valuable advice (though they must not be regarded as responsible for any opinion here expressed).

Summary

(1) A cell is defined as a mass of protoplasm, largely or completely bounded by a membrane, and containing within it a single nucleus formed by the telophase transformation of a haploid or diploid set of anaphase chromosomes.

(2) It is argued that many algæ and Protozoa are properly regarded as unicellular organisms.

(3) Certain Protozoa, notably the Radiolaria and Ciliophora, are not cells in the sense of the definition given above.

(4) It is argued that there is no fundamental difference between the cleavage of an egg and the multiplication of a unicellular protozoan by division.

(5) It is not unlikely that Metazoa may have arisen by the failure of unicellular Protozoa to separate after division.

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THE BORDERLINE OF PSYCHOLOGY, PHYSICS AND MUSIC

AT a meeting of the Acoustics Group of the Physical Society, held in the Science Museum, South Kensington, on February 12, three speakers contributed to a symposium on "The Borderline of Psychology, Physics and Music". The chairman was Mr. H. L. Kirke, head of the Research Department of the B.B.C. and chairman of the Acoustics Group.

Prof. Balth. van der Pol was the first speaker and he dealt with three problems: (*a*) the mathematical theory of consonance; (*b*) intonation from a purely musical point of view; and (*c*) absolute pitch.

In his discussion of the mathematical theory of consonance, Prof. van der Pol directed attention to the work of Leonhard Euler, who, in 1739, gave in his "Tentamen novæ theoriæ musicæ" a rigorous numerical measure for the "gradus suavitatis" or euphonic value of consonances and dissonances. This measure was the ratio of the least common multiple to the greatest common divisor of the frequencies of the component notes. Prof. van der Pol showed a table of the euphonic values of twenty-four 2-note, six 3-note and two 4-note combinations. It was clear that these euphonic values corresponded with the purely musical impressions of the relative consonances of the intervals and chords in question. The euphonic values of several familiar intervals are: unison, 1; octave, 2; twelfth and fifteenth, 3; fifth, 4; fourth, 5; tenth and eleventh, 6; greater sixth, 7; lesser and greater major second and lesser sixth, 8; lesser and greater seventh, 9; lesser major second and augmented seventh, 10.

Both Euler and Huygens suggested the introduction into music of the prime number 7, as all musical intervals used before could be represented by $2^l 3^m 5^n$, which led Leibnitz to state that musicians could count up to five only. Both suggested the dominant seventh chord: $g\ b\ d'\ f' = 4, 5, 6, 7$. The seventh of this chord, however, is too flat for musical purposes, as Prof. van der Pol demonstrated with an oscillator, with which he sounded the notes both separately and together. He showed that the chord 36, 45, 54, 64, the diatonic dominant seventh, is musically satisfying. The euphonic values of these two chords are 15 and 17, and it is clear that musicians would prefer the more dissonant of the two for æsthetic reasons.

On the matter of intonation from a purely musical point of view, Prof. van der Pol put forward the idea that the pitch of a note played is legitimately variable to a certain extent at the performer's discretion, just as the executant has some freedom in the matter of rhythmic interpretation. The intonation of *E* in the chord of *C* major may depend on its function as the third of the chord. In brilliant music, a sharp (Pythagorean) third will accentuate the typical and unmistakable quality of a major chord. Probably Beethoven was aware of this, though without knowledge of the underlying mathematical theory, when he indicated in the last movement of his Fifth Symphony, that the second note of the first bar should be an open *E* string. Similarly, in the main theme of Wagner's Meistersinger overture, also in *C* major, a sharp third should be played. The pitch of a note and its effect will, in fact, depend on the musical context.

A low third (the diatonic 5 : 4) will be appropriate in soft and floating music such as a lullaby. The leading note of the dominant seventh, thrusting towards the tonic, is not seldom sung too high, and often, indeed, the composer anticipates the tonic in his closing harmony. A Neapolitan sixth ($D\flat$ in the chord *F*, $A\flat$, $D\flat$, in *C* major or minor) can, with advantage, be sounded low, because it leads down to the tonic.

Prof. van der Pol concluded with an account of experiments on the measurement of changes in absolute pitch, carried out on himself in 1939, with an oscillator by means of which a note of any desired pitch could be produced. During a fortnight, eighteen independent measurements of an *A* were made, as most closely conforming to his absolute pitch for that note. The estimates had a mean value of 435·2 c./s., with a mean deviation of 3·3 c./s. The greatest 'error' was 6·2 c./s., or a quarter tone. He explained that absolute pitch sometimes tends to vary in the course of years. The absolute pitch of a physicist friend of his had fallen 1·5 tones when he was about eighty years of age. Prof. Klein of Utrecht had communicated to him that the absolute pitch of the Dutch composer Wagenaar had remained unchanged up to his death at the age of seventy-nine.

The second contribution to the symposium was made by Dr. R. W. Pickford, who described three experiments on the relation of the impression of dissonance to the context of a chord. All the experiments were done by rating the critical chords on a 7-point scale running from −3 (very dissonant) to +3 (very consonant). Liking and disliking were

kept apart, and in the third experiment these qualities were also rated in the same way. In the first experiment, forty women and eight men took part, and twelve chords were rated, each in six different settings and by itself. In the second, forty-three women and seven men rated fourteen chords in all of which the actual notes were identical. They were in settings mostly taken from familiar pieces of music. In the third, forty women and ten men rated fourteen chords in all of which the notes were identical, and which were in settings specially constructed for the experiment. The piano was the instrument used throughout. In the first experiment 'clang' effects were exploited, and in the other two interest was concentrated upon the musical preparation and resolution of dissonances.

It was found that familiar dissonances were given all kinds of ratings from very consonant to very dissonant, but most often they were classed as moderately dissonant, a seventh being classed on the average as less dissonant than a ninth, so that the average results were appropriate to musical expectation. There was a strong tendency for the consonance-dissonance level of chords to vary (*a*) with the context and (*b*) with the individual subjects' peculiarities of musical attitude and experience. Nevertheless, the chords had a strong tendency to retain their relative dissonance-levels in spite of these variations. There was a moderate tendency for liking to go with the impression of consonance, and disliking with that of dissonance. Smooth musical handling of dissonances tended to lead to the impression of consonance and also to liking, but departure from smooth handling led to various other combinations of liking, disliking, consonance and dissonance. The subjects were always astonished when told that they had rated the same note-combinations in different settings.

Helmholtz's theory of fusion appeared to provide the most satisfactory explanation of consonance and dissonance, apart from the effects of musical setting and individual attitudes of listeners. A Gestalt or 'form' theory of the effect upon the dissonance-consonance level of individual chords owing to their integral membership of whole passages or contexts should be added, together with a theory of personal schemata due to differences in musical ability and experience of individual listeners. Further experiments should be carried out on the relative effects of various musical techniques in handling dissonances and of 'clang' effects upon dissonance-consonance levels, and to compare these effects for pure tones and notes of complex timbre.

The third contribution to the symposium was made by Mr. J. Steuart Wilson. He pointed out that there are unfortunate tendencies at present to exploit the performer's capacity to vary the intonation of the intervals he sang or played. This is particularly noticeable in 'jazz' and 'swing', in which it has become an objectionable form of virtuosity. Even among serious musicians, some teachers trained their pupils to vary the intonation in playing classical music to produce special effects. Sometimes this had unfortunate results, because of the variety of thirds, for example, which might be included in a major common chord played by an orchestra. In addition, the liberties taken in 'jazz' and 'swing' had taught the public to like some effects which classical musicians eschewed, with the result that they thought that serious music was intolerably dull when it was really well played.

In the discussion the main speakers agreed that slight adaptations of pitch to suit the musical needs of a passage might be justified, provided that this did not lead to intolerably slovenly performance or to a form of senseless virtuosity. They also agreed that the impression of harshness of a dissonance might be expected to vary according to the way in which it was used. Mr. Steuart Wilson thought it most unfortunate that so many peoples' ideas of musical intervals came from listening to the pianoforte, which was often badly tuned either because nobody looked after it or because there was none to criticize the work of the tuner.

Dr. Dennis Fry pointed out that many people with absolute pitch are able to assign pitch to a sound which, for the majority, seems to be a noise without definite pitch. He asked whether people with absolute pitch might have two abilities, possibly separate in some cases: first, the permanent memory for pitch enabling them to compare pitches without reference to an external standard; and second, the ability to assign pitch to a frequency complex containing strong inharmonic components. In reply, Prof. van der Pol said that it is easier for most persons who have absolute pitch to assign pitches to notes which have many overtones than to pure single tones.

Dr. Fry asked whether the pitch of a given tone of fairly low frequency, say Middle *C*, 261 c./s., is recognized by a person with absolute pitch regardless of its intensity. If not, then at what intensity-level would it become Middle *C*? Also he thought it would be interesting to know what loudness-level of a pure tone of 261 c./s. gives rise to a pitch sensation exactly equal to that of a frequency complex containing a number of terms with a constant difference of 261 c./s. between them. Prof. van der Pol demonstrated the effect of varying the intensity of a given tone with his oscillator, but did not think data were available for answering the questions asked by Dr. Fry. It was suggested by Dr. Pickford that a valuable piece of research could be carried out in which adequate psychological experiments were performed with a large group of persons having various degrees of absolute pitch, in order to find out more about its variations among individuals, which might be very great. He also suggested that the euphonic value of an interval or chord, as defined by Euler, did not in itself determine the dissonance level of that chord. The only way to determine the euphonic value which would correspond to dissonance rather than to consonance would be to study the average of individual judgments and their variability. Most people would think that a euphonic value of 8 was dissonant; but the only way to determine this would be that of experimenting with large numbers of subjects.

R. W. Pickford

OBITUARIES

Prof. M. C. Potter

At the age of eighty-nine, Emeritus Professor the Rev. Michael Cressé Potter died on March 9 at New Milton, Hampshire, where he had lived since his retirement in 1925 from the chair of botany at Armstrong College (now King's College), Newcastle upon Tyne.

In 1877, Potter left the Perse School, Cambridge, and entered Peterhouse, where his father, who was

rector of Corley, had preceded him and his uncle, the Rev. Canon Potter, had been a fellow. As, in addition, another uncle, Prof. Richard Potter, was a fellow of Queens', Potter rightly regarded himself as a well-established Cambridge man. He was ardent in support of his University on all public occasions. As an undergraduate he read natural science and graduated in 1881. He then read for the Mathematical Tripos, and in 1883 was classed senior optime. Shortly afterwards he was appointed to the post of assistant curator of the Herbarium under Prof. C. C. Babington, which became vacant through the tragic death by drowning of T. H. Corry. He assisted Dr. Walter Gardiner in re-establishing the University Botanical Museum, which had been founded by Prof. Henslow, and in commencing the preservation of botanical specimens in spirit.

Potter began his academic work when what was then known as the 'new botany', introduced by McNab at Dublin and by Huxley and Dyer at South Kensington, was coming to the fore, and when practical laboratory investigation was being developed at Cambridge under the direction of the reader, S. H. Vines. He stressed the new ideas, and the economic importance of plants, in the long-vacation course of lectures he gave on systematic botany, and he arranged excursions and laboratory work. He delivered the first course of lectures given at Cambridge on the geographical distribution of plants. On two occasions he was awarded a Wort's travelling scholarship. In 1886 he went to Portugal and made observations on an alga which lived parasitically on the carapace of the water tortoise. In 1888–89 he studied the tropical flora in Ceylon.

In addition to these travels, Potter went to Heidelberg and attended Prof. Pfitzer's lectures there. He thus became familiar with the Continental system of classification, and used it in his lectures on systematic botany. In 1894 he translated and edited Dr. E. Warming's "Handbog i den Systematiske Botanik" in order to introduce this system to English-speaking botanists.

In 1889, after six years of rich experience, Potter took up a lectureship in botany and biology at Newcastle upon Tyne. In his first term there were only five students in natural history, none reading for a degree. In 1892 a chair was instituted, and Potter was its first occupant. Potter, who could be a determined man, eventually won his uphill fight to secure the recognition of botany as an independent subject at the intermediate and final pass and honours degree examinations. A measure of the success with which he built is the fact that on his retirement from the chair in 1925 he had four lecturers on his staff, and his department, which was fairly well equipped, could accommodate in reasonable comfort the 167 students of pure science, agriculture and medicine who were then attending courses in it.

The link between the Departments of Botany and Agriculture has always been strong. Potter did much in establishing it. The content of his course for agricultural students is indicated by that of his elementary "Text-book of Agricultural Botany", which was published in 1893. He also took evening classes for farmers and gardeners. He became interested in problems of plant pathology, and his researches culminated in the major discovery in 1899 that white-rot of turnips is caused by a bacterium, which he named *Pseudomonas destructans*. In his presidential address to the British Mycological Society in 1909 he gave the evidence that led to the recognition of bacterial diseases of plants, and placed his contribution in its historical setting. His interest in plant pathology and economic mycology was maintained throughout his life, and the subject received much attention in the curriculum he devised for students in science and in agriculture at Newcastle.

As a teacher and examiner, Potter laid great emphasis on experimental physiology. From 1895 (the date of publication of Darwin and Acton's book) onwards, students carried out experiments, even in the elementary agricultural and medical classes and examinations. Potter believed that, in those early days, the University of Durham's schools examination was unique in requiring a practical examination in botany in which each candidate was required to set up and explain a simple experiment and to determine a plant by means of a flora.

Some may regret that after 1910 his main research interest was transferred from plant pathology to electrophysiology, through his reading Dr. A. D. Waller's "Signs of Life". Physicists who knew about his work thought that such effects as he obtained were open to interpretations other than those he put on them. He held tenaciously to the idea that electrical effects accompany metabolism and are of primary importance in determining cellular activity. He may have been right. Who knows?

During the First World War Potter showed his ardour by acting for a period as a volunteer in a Newcastle signalling unit raised for home defence, and later by taking Holy orders to relieve younger clergymen required by the Forces. Among his hobbies were campanology and dowsing.

M. THOMAS

Prof. E. Waymouth Reid, F.R.S.

THE death of Prof. E. Waymouth Reid in Edinburgh on March 10 has taken from us one of the pioneers of British physiology. Born in 1863 in Canterbury, the son of a surgeon, he was educated in Sutton Valence Grammar School, and went as a classical scholar to the University of Cambridge. After taking a first-class in anatomy and physiology in the Natural Sciences Tripos in 1883, Waymouth Reid worked in St. Bartholomew's Hospital, and graduated M.B. Thereafter he was for a time assistant electrician in St. Bartholomew's, but soon began his life's work as a physiologist, first as demonstrator and then as lecturer in St. Mary's Hospital Medical School. At the early age of twenty-seven he was appointed to the newly established chair of physiology in University College, Dundee, where he joined a body of highly gifted men who held teaching posts in the recently formed College affiliated to the University of St. Andrews. Waymouth Reid served the University for forty-six years, and after his retirement in 1935 the University of St. Andrews conferred upon him an honorary degree of LL.D.

Waymouth Reid showed his ability in the number and versatility of the published records of his research work. He contributed in 1898 noteworthy articles to Schäfer's "Text-book of Physiology" on diffusion, osmosis and filtration, and on secretion and absorption by the skin; and papers in journals on a diversity of topics. He was made a fellow of the Royal Society in 1889, and later on received the honorary degree of Sc.D. from the University of Cambridge.

Waymouth Reid was especially interested in the physical mechanisms of living processes and kept in touch with modern developments. He was an early

worker with X-rays, and investigated their effects on the animal organism, using his own body to its detriment. He was an expert photographer, and his laboratory was at one time richly equipped with apparatus for experimental purposes. At another time he occupied his spare time in the making of elaborate sweetmeats. He was always busy, and everything he did was done thoroughly.

He was largely instrumental in the development of what is now a very big and important concern, namely, the examination and reporting upon pathological material sent in to the College by medical practitioners in Angus, Fife and Perthshire. Much of the early work was done by Waymouth Reid himself, but it became so big that the University Court had to take it over and make special provision for it in the Department of Bacteriology.

Waymouth Reid was a good teacher and did not neglect that side of his Department's work. He was concise, humorous on occasions, and was liked and respected by his students. For some time he acted as dean of the Medical Faculty of the University, and took his share of administrative work. He was for a period one of the editors of the *Journal of Physiology*, a vice-president of the Section of Physiology at the annual meeting of the British Medical Association in 1898, and president of the Dundee Branch during 1903–4. He also acted as external examiner in physiology for the Royal College of Surgeons, the University of Cambridge, and the Royal College of Veterinary Surgeons.

On his retirement Waymouth Reid went to live in Edinburgh, but failing health lessened his activities, though he retained his mental acuity.

P. T. Herring

We regret to announce the following deaths:

Prof. F. O. Bower, F.R.S., professor of botany in the University of Glasgow for more than forty years, on April 11, aged ninety-two years.

Prof. Alexander Ogg, formerly professor of physics in the University of Cape Town, and a past-president of the Royal Society of South Africa, on February 23.

NEWS and VIEWS

Institution of Civil Engineers: James Alfred Ewing Medal

On the joint recommendation of the presidents of the Royal Society and the Institution of Civil Engineers, the Council of the Institution of Civil Engineers has awarded the James Alfred Ewing Medal for 1947 to Sir John Cockcroft, for specially meritorious contributions to the science of engineering in the field of research. The medal is awarded annually and was founded in 1936 in memory of Sir Alfred Ewing. Sir John Cockcroft succeeded Sir Edward Appleton in May 1939 as Jacksonian professor of natural philosophy in the University of Cambridge. During the War he became director of the Air Defence Research and Experimental Establishment of the Ministry of Supply and a member of the Ministry's Advisory Council on Scientific Research and Technical Development. Later he became director of the Montreal Laboratory of the National Research Council of Canada, and of the Canadian Experimental Atomic Research Plant until early in 1946, when he was appointed director of the Atomic Energy Research and Development Establishment, Harwell, Didcot, formed under the Ministry of Supply to deal with all aspects of the use of atomic energy. He has published various papers on nuclear physics and also on technical subjects. In 1936 he delivered the thirty-seventh Kelvin Lecture before the Institution of Electrical Engineers, taking as his subject "The Transmutation of Matter by High-Energy Particles and Radiators". In 1946 he received the Hopkins Prize from the Cambridge Philosophical Society for researches carried out during the period 1933–39 on the artificial transmutation of elements. Sir John Cockcroft has been concerned with most of the major achievements of the Cavendish Laboratory during the past sixteen years, his advice having been sought on the design of much of its special equipment; he took a leading part in the construction of the cyclotron at Cambridge.

Hatfield Memorial Lecture of the Iron and Steel Institute: Prof. Robert E. Mehl

The third Hatfield Memorial Lecture of the Iron and Steel Institute will be delivered in London on May 5, in connexion with the annual general meeting of this Institute, by Prof. Robert E. Mehl, of the Carnegie Institute of Pittsburgh. Prof. Mehl, who was born in Lancaster, Pa., on March 30, 1898, received his early training at Franklin and Marshall College, Lancaster, Pa., proceeding eventually to Princeton University, and, as a national research fellow, to Harvard University. He then became superintendent of the Division of Physical Metallurgy at the Naval Research Laboratory, Washington, D.C. (1927–31), inaugurating this division. In 1932 he became director of the Metals Research Laboratory and professor of metallurgy at the Carnegie Institute of Technology, Pittsburgh, Pa., and in 1935 head of the Department of Metallurgical Engineering in the Institute. Prof. Mehl has published many papers on the constitution of alloys, crystal structure, radiography, the electron microscope, the properties of forging steels, general metallurgy, theory of age-hardening, heat-treatment of steel, etc. He translated Gustav Tammann's book on "The States of Aggregation" (1925) and published his own book on the "Metallurgy of Iron and Steel" (in Portuguese) in Sao Paulo in 1944. His "History of Physical Metallurgy" was issued this year by the American Institute of Mining and Metallurgical Engineers.

Royal Zoological Society of Scotland

The President and Council of the Zoological Society of Scotland have been informed by the Secretary of State for Scotland that the King has been graciously pleased to grant to the Society the privilege of prefixing the title "Royal" to its name, so that the proper title of the Society is now the Royal Zoological Society of Scotland. The Society,

which is of national status, was formed in 1909 and was incorporated by Royal Charter in 1913, when the Scottish National Zoological Park, which it owns and controls, was founded. The Park has had the honour of several Royal visits and has been the recipient of a number of Royal gifts of animals.

August Gärtner (1848–1934)

NESTOR of German hygiene, August Anton Hieronymus Gärtner, whose name is familiar to every medical student in Gärtner's Bacillus (*Salmonella enteritidis*), was born on April 18, 1848, at Ochtrub, Westphalia. He served in the Franco–Prussian War of 1870–71, and in 1884 became assistant to Robert Koch at the Kaiserliche Gesundheitsamt, Berlin. Two years later he was appointed to the chair of hygiene at the University of Jena, which he held until his retirement in 1914. As a teacher he was immensely popular, his genial personality endearing him to students and colleagues alike. It was in 1888, during an outbreak of meat poisoning in Frankenhausen on the Kyffhäuser, that he succeeded in growing the bacillus ever since known by his name. To the literature of hygiene he contributed his classic "Die Hygiene des Trinkwassers (1897), "Die Hygiene des Wassers" (1915), and, in co-operation with Ferdinand Tiemann, "Handbuch der Untersuchung und Beurteilung des Wassers" (1889–95). His "Leitfaden der Hygiene" was first published in 1892; a tenth edition was issued in 1923, and a French translation in 1895. In the First World War Gärtner served as 'Kriegssanitätsinspekteur' of prisoner-of-war camps. Preserving excellent health into advanced age, he died at Jena on December 21, 1934, in his eighty-seventh year. His autobiography appeared in *Centralblatt für Bakteriologie*, **107**, 1, ii (1928).

Royal Aeronautical Society: Awards

THE following medals and awards have been made by the Council of the Royal Aeronautical Society: *Society's Gold Medal*: Sir Bennett Melvill Jones, for his outstanding work in aerodynamics; *Society's Silver Medal*: I. I. Sikorsky, for his work on the development of the helicopter; *Society's Bronze Medal*: Miss F. B. Bradfield, for her work on aeronautical research; *Simms Gold Medal*: Sir William T. Griffith, for his paper "The Problem of High Temperature Alloys for Gas Turbines"; *George Taylor (of Australia) Gold Medal*: Dr. J. W. Drinkwater and W. G. Glendinning, for their paper on "The Risk of Fire and Fire Prevention Methods"; *Edward Busk Memorial Prize*: Air Marshal the Hon. Sir Ralph Cochrane, for his paper on "The Development of Air Transport During the War"; *R.38 Memorial Prize*: W. M. Widgery, for his paper on "Pressurisation of Aircraft"; *Branch Prize*, awarded for the best paper on an aeronautical subject read before the branches of the Society: A. N. Clifton, for his paper on "Naval Aircraft" read before the Southampton Branch, and J. A. Kirk, for his paper on "Wind Tunnels" read before the Belfast Branch.

Courtaulds' Scientific and Educational Trust Fund

MESSRS. COURTAULDS, LTD., have announced the formation of the Courtaulds' Scientific and Educational Trust Fund, which has been formed with the object of encouraging study and research in those branches of natural science likely to assist the textile, plastics or other allied industries. The Fund provides for the establishment and maintenance of scholarships, and the provision of laboratory apparatus and equipment for education and research institutions. The Company will pay to the trustees the sum of £105,000, less tax, over a period of seven years. The trustees are Sir Edward Appleton, Sir Charles Tennyson, and, representing Courtaulds, Ltd., Mr. J. C. Hanbury-Williams (chairman), Mr. R. A. Butler, M.P., and Mr. R. A. Kinnes. The Trust will be administered by a management committee of representatives from the Company, together with Prof. C. N. Hinshelwood (University of Oxford), Prof. D. M. Newitt (University of London), and Prof. J. B. Speakman (University of Leeds).

Atomic Energy Commission Fellowships

THE U.S. National Research Council has announced a new programme of fellowships supported by funds provided by the Atomic Energy Commission as a part of the Commission's responsibility for future atomic energy research. These fellowships will be awarded in the many fields of science related to research in atomic energy and the products of atomic energy processes. Some of the fellowships are available to those who wish to continue in graduate training or research for the doctorate in an appropriate field of science; others will provide training in biophysics applied to the control of radiation hazards. Further fellowships will be awarded to candidates less than thirty-five years old who have already obtained a doctorate and who wish to secure advanced research training and experience in aspects of the physical, biological and medical sciences related to atomic energy. The programme provides for two groups of fellows in the pre-doctoral field. One group will work in the biological and basic medical sciences, including applied biophysics, relating to the measurement and control of radiation hazards and the effect of radiation upon health; another group will be selected for study and research in the general field of the physical sciences. Awards will be made for the academic year 1948–49. Further information can be obtained from the Fellowship Office, National Research Council, 2101 Constitution Avenue, Washington 25, D.C.

American Summer Scholarships for European Students

THE Massachusetts Institute of Technology, in co-operation with the students at the Institute, is offering approximately eighty scholarships to European students for study there for the period June 14–September 17. A certain proportion of these scholarships have been reserved for students in Great Britain. Any science or engineering student, male or female, who has completed approximately four years of university study, or any person who has recently graduated in the fields of science or engineering, is eligible; applicants must be more than thirty-five. All expenses will be paid by the Institute, with the exception of the cost of the trans-Atlantic passage, which may cost approximately £70 for the round trip. The summer seminar offers advanced courses in civilian and sanitary engineering, mechanical engineering, metallurgy, aeronautical engineering, architecture and planning, building engineering and construction, chemistry, electrical engineering, physics and chemical engineering. Further information concerning the subjects of instruction can be obtained from the Chief Scientific Officer in the United States Embassy, 5 Grosvenor Square, London, W.1. The last date for submission of applications is April 30.

Discovery of a Living *Metasequoia* in China

UNDOUBTEDLY one of the most interesting recent additions to our knowledge of the Chinese flora is the discovery of a 'new' conifer thought to be congeneric with Mesozoic fossil forms originally ascribed to *Sequoia* but now placed in a separate genus *Metasequoia*, as *M. Heerii*, *M. japonica*, *M. disticha* and *M. chinensis*. The living species of *Metasequoia* was discovered in north-eastern Szechwan in 1945, but is now known to occur more abundantly in Hupeh province. It occupies, however, only a limited area, and there is a grave danger that felling of the trees may lead to its extinction. Thanks, however, to the enterprise of the Arnold Arboretum of Harvard University and the co-operation of Chinese botanists, a special expedition last year obtained an ample supply of seed, and seedlings are now being raised in Britain as well as in the United States. The tree grows to a height of at least 115 ft., with a trunk diameter of at least 7½ ft., and is deciduous. In general appearance it is not unlike a *Glyptostrobus*. An account by Prof. E. D. Merrill of the discovery and introduction of this new *Metasequoia* has recently been published in *Arnoldia* (**8**, 1; March 1948).

British Fauna

THE Linnean Society of London is to be congratulated upon initiating a very useful piece of work in its "Synopses of the British Fauna", of which the first number was published in January 1944 and the most recent, No. 7, in 1947. The need for such synopses, particularly in the groups which do not attract the ordinary collector, like, say, Lepidoptera and Coleoptera, has long been felt by zoologists, naturalists and ecologists. The numbers so far published in order of appearance are: (1) Opiliones; (2) Caprellidea; (3) Gammaridæ; (4) Freshwater Bivalves; (5) Freshwater Bivalves (Unionacea); (6) Lumbricidæ; and (7) Talitridæ. The synopses are well printed, illustrated and provided with keys which in the two groups that have been used by the reviewer on several occasions are not difficult to use and do work. The price is reasonable, 2*s*. 6*d*., save for the largest, which is 5*s*. Individual numbers will naturally appeal to workers in their particular fields; but no institution that is likely to be concerned, however remotely, with faunistic work can afford to be without the complete set. It is to be hoped that the paper restriction will not slow down the rate of publication, or lead to the printing of insufficient copies of these synopses.

Research at the University of Birmingham

THE eighteenth annual report of the Joint Standing Committee for Research of the University of Birmingham, which covers the sessions 1938–39 to 1946–47, is a reference document of exceptional interest. The first section, covering the years from 1938–39 to 1945–46, gives a summary of the research carried out in the various departments of the Faculties of Science, Arts, Medicine and Commerce and also by the University Library, the Board of Research for Mental Disease, the Cancer Research Laboratory, and the Radiotherapy Department, Birmingham United Hospital. The summaries or notes on these researches are supported by full lists of publications under the Departments concerned. The second section of the report, covering the session 1946–47, in addition to a like list of publications embodying results of research completed in 1946–47, lists the personnel of the Committee, the research funds available for the session 1946–47, the conditions and procedure relating to applications for grants, the subjects of research towards which grants-in-aid have been made by the Committee and also other subjects of research during the session.

Atmosphere of Mars

THE December issue of *Sky and Telescope* contains a short note on the atmosphere of Mars, which describes the work of Dr. G. P. Kuiper, of the Yerkes and McDonald Observatories, on this subject. Using an infra-red spectrometer employing a Cashman lead-sulphide cell a thousand times more sensitive than any previous instruments of this type, Dr. Kuiper has examined the spectra of celestial objects at wave-lengths of 1–2·5 microns, and has found that the atmosphere of Mars contains at least as much carbon dioxide as does the earth's atmosphere. Methane and ammonia appear to be absent. Dr. Kuiper believes that the Martian polar caps are probably ordinary snow and clouds of water vapour, and he was hoping to test this on February 17 when Mars was at opposition and near aphelion. If the polar cap visible at that time is sufficiently large for his test, it will be possible to measure the amount of water vapour on the planet with the new instrument.

Catalogue of Medical Films

THE Catalogue of Medical Films compiled by the Royal Society of Medicine and the Scientific Film Association, which are referred to in the catalogue as RSM and SFA respectively (ASLIB, 52 Bloomsbury Street, W.C.1, 1948. 7*s*. 6*d*. and 6*s*. to members of ASLIB and SFA), is a very useful small volume. It is the outcome of collaboration, suggested by the Royal Society of Medicine when it was considering the formation of a library of medical films. By March, 1946, more than 1,200 titles of films had been collected from lists held by commercial firms, medical schools and societies, university departments and private individuals. All the material thus collected has been entrusted to the care of the Scientific Film Association, to which all inquiries about it should be addressed (34 Soho Square, London, W.1). Eight hundred of the films have been viewed, and Part 1 of the catalogue groups them by subjects and catalogue numbers. Part 2 gives details of the availability of two hundred of the films. It shows that they come from various sources in Britain, Europe and the United States, and range from elementary instructional films suitable for health education of the lay public to films of difficult surgical operations and similar subjects suitable only for medical and scientific audiences. All the films listed in Part 2 are available, and more than one copy of each exists. Many other films not listed in Part 1 are also now available, and details of these can be obtained from the medical cataloguer of the Scientific Film Association.

Origins of Central American Culture

IN "Some Implications of the Ceramic Complex of La Venta" (*Smithsonian Misc. Coll.*, **107**, No. 8), Dr. Philip Drucker presents an interim report on this important site in southern Mexico. The name has recently been applied to an early culture found at this and neighbouring sites, but he prefers the older term 'Olmec', which was abandoned owing to its association with a tribe inhabiting the area in historic times, because La Venta does not provide the most

complete succession. The La Venta ceramics correspond, in fact, to the middle period only of the succession at the neighbouring site of Tres Zapotes. He gives an outline of the distribution of the culture, the centre of which is on the Gulf Coast of the Isthmus of Tehuantepec, showing how closely it is restricted in at least two directions by geographical obstacles. There is reason for believing that its markedly individual and well-known characteristics, which are seen in the sculpture rather than in the pottery, are due to development in place and not to outside stimuli. This conclusion is very important, since it cuts at the root of the idea, recently repeated in Morley's new book on the Maya, that that talented people was the fount of all Central American civilization.

Indian Society for Quality Control

An Indian Society for Quality Control, "to promote the advancement and diffusion of knowledge of the science of Quality Control and of its application to industrial processes", has been formed at Calcutta. A committee consisting of engineers, industrialists and statisticians has been set up to conduct the affairs of the Society. Mr. B. K. Rohatgi (director, India Fans, Ltd., and president of the Engineers Association of India) is president, and Prof. P. C. Mahalanobis is among the members of committee. Mr. R. D. Vidyarthi (102-A, Netaji Subhas Road, Calcutta) and Mr. N. T. Mathew (Indian Statistical Institute, Presidency College, Calcutta) are secretaries.

National Research Council of Canada : Publications

The second edition (1947) of Publications of the National Research Council of Canada (Ottawa) lists by authors and subjects all papers issued by it up to the end of 1946, these lists merely citing, however, the serial numbers of the publications in the "N.R.C." series. The major part of the document consists of a serial list of these publications, giving the full title, bibliographical reference if published elsewhere and the price of the reprint or paper in the N.R.C. series, up to number 1412. The *Canadian Journal of Research* has its own volume and number series, and for this reason is not included in the "N.R.C." series, although reprints of certain papers from it have been included.

Announcements

Prof. R. C. Punnett, formerly Arthur Balfour professor of genetics in the University of Cambridge, and Prof. A. H. Sturtevant, professor of genetics in the California Institute of Technology, Pasadena, California, have been elected honorary members of the Genetical Society of Great Britain, in recognition of their outstanding contributions to the science of genetics.

Dr. G. S. Hartley has been appointed research manager of Messrs. Pest Control, Ltd., Harston, to take charge of the Chemical Research Department. The company's research programme has for some time been devoted to the development of helicopter spraying, the formulation of aero spray chemicals and the development of selective insecticides to supplement biological control by chemical control on agricultural and horticultural crops in Great Britain, Europe and Africa.

Mr. R. H. Myers, head of the Steelmaking Division of the British Iron and Steel Research Association, has retired on account of ill-health. He is succeeded by Dr. A. H. Leckie, formerly deputy head of the Division.

The Challenger Society is prepared to consider applications for small grants in aid of research in marine biology or oceanography at a recognized laboratory during the year June 1948–June 1949. Applications, accompanied by details of the proposed research, should reach the Honorary Secretary, Mr. Dilwyn John, British Museum (Natural History), London, S.W.7, before the end of May.

Applications are invited for the John Gray Jubilee Scholarship of the Society of Chemical Industry, value £150, tenable for one year at any approved university or technical college. Candidates, who may be of either sex, should be graduates in chemistry whose intention is to enter industry, but those awaiting the result of their final degree examination may apply. Preference will be given to the son of a member of the Society of ten or more years standing. Applications must be made before July 10 to the General Secretary, Society of Chemical Industry, 56 Victoria Street, London, S.W.1.

A Busk studentship in aeronautics will be awarded during June. The studentship is of the value of about £165, tenable for one year from October 1; but a student may be reappointed on the same terms for a second year. It is open to any man or woman being a British subject and of British descent who has not attained the age of twenty-five years on October 1. Forms of application for the studentship, to be returned by June 1, can be obtained from the Professor of Aeronautical Engineering, Engineering Laboratory, Cambridge.

The first post-war exhibition of German books, periodicals and newspapers from all the occupied zones will be opened by Lord Pakenham on April 19, at 4 p.m., at the Academy Hall, Oxford Street, London, and will remain open for a week. The exhibition is being organised by European Periodicals Publicity and Advertising Co., Ltd., 2, 3 and 5 Studio Place, Kinnerton Street, London, S.W.1, with the view of stimulating the flow of scientific and cultural works from Germany to the rest of the world.

A short course for teachers of chemistry in technical colleges will be held at the Sir John Cass Technical Institute, London, E.C.3, during July 5–16. The main substance of the course will be the theory and practice of micro- and semimicro-inorganic analysis; spectroscopic analysis; small-scale organic preparative methods; electrochemical methods of analysis. There will also be lectures and discussions on teaching methods and recent developments. Visits to works will be arranged. Forms of application may be obtained from any local education authority for further education, or from the Ministry of Education (Short Courses), 14–22 Lennox Gardens, London, S.W.1. The closing date for application is May 15.

We have received from Messrs. Plant Protection, Ltd., Nobel House, London, S.W.1, a well-produced booklet on their 'Agrocide' range of insecticides. These are based on the synthetic compound 'Gammexane' discovered by Imperial Chemical Industries in 1942. In order that 'Gammexane' may be used in the most economical and efficient manner, Plant Protection have formulated its mixture with powders, solvents, etc. The results described are extremely encouraging and include the control of diverse insect types attacking a wide range of crops in many parts of the world.

LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications

Velocity of Meteors Measured by Diffraction of Radio Waves from Trails during Formation

It is now well established that when a meteor enters the earth's atmosphere it creates a trail of electrons at a height of approximately 100 km.[1–4]. During the 1946 Giacobinid shower, Hey, Parsons and Stewart[5] measured the velocity of densely ionizing meteors by observing the radio wave scattered from the ionization at the head of the approaching meteor. We have recently succeeded in detecting the diffraction pattern of radio waves scattered from the electron trail as a meteor passes at right angles through the aerial beam. These observations lead directly to a measurement of the velocity of the meteor.

The basic transmitting and receiving equipment operating on a wave-length of 4·2 metres has already been described[2,3]. The additional apparatus consisted of a single-stroke time-base of duration 0·2 sec. on a separate cathode ray tube. The time base was automatically triggered by the radio echo from the meteor, and a photograph obtained of the successive pulse amplitudes occurring in the first 0·2 sec. of the echo. An example is shown in **Fig. 1**. The received power varies in an oscillatory manner, and the time intervals between maxima and minima are measurable from the photograph.

Fig. 1. Quadrantid meteor. January 4, 1948, 05h. 01m. Zone maxima marked by arrows. Range 440 km. Measured velocity = 34·7 ± 2·2 km./sec. Interval between pulses = 1·6 millisec. Exponential time base

It can be shown theoretically that the variation in the received power, as a meteor trail crosses the region about the perpendicular from the station, should be given by Fresnel's integrals, corresponding to the optical case of diffraction of light at a straight edge. The relative amplitudes of successive zones will not necessarily be given by the Fresnel integrals, owing to the non-linearity of the ionization along the trail[6]; but it will be shown that the *zone-lengths* obtained experimentally from individual meteor photographs agree with the zone-lengths given by the Fresnel integrals.

Calculation of the Fresnel integrals for a spherical wave gives values of the radii of successive zones, and subtraction between pairs of these values gives the theoretical zone widths, shown in Table 1, where R is the range and λ the wave-length. A, C, E are successive maxima, and B, D, F successive minima; A being the first maximum.

Table 1

$AC = 0{\cdot}55\sqrt{R\lambda}$	$CE = 0{\cdot}36\sqrt{R\lambda}$
$BD = 0{\cdot}43\sqrt{R\lambda}$	$DF = 0{\cdot}33\sqrt{R\lambda}$

In Table 2 the theoretical ratios of various zone widths are given, together with the equivalent ratios of four experimentally measured meteors at different ranges typical of forty-four obtained during the Geminid and Quadrantid showers of December 11–13, 1947, and January 4, 1948. It is assumed that the velocity of an individual meteor remains constant during the traverse of the zones, so that the measured number of pulses in the zone intervals considered is proportional to the length of the zones. The third meteor tabulated did not show a measurable F minimum.

Table 2

Ratios of zone	Theoretical	Experimental ratios (Quadrantid meteors) 1 360 km.	2 110 km.	3 470 km.	4 400 km.
AC/DF	1·68	1·59	1·57	—	1·88
AC/CE	1·52	1·56	1·50	1·48	1·61
BD/DF	1·32	1·16	1·38	—	1·36
AC/BD	1·27	1·37	1·13	1·28	1·38
BD/CE	1·19	1·14	1·32	1·15	1·16
CE/DF	1·11	1·01	1·05	—	1·17

Within the limits of experimental error, the ratios of the zone spacings agree with the theoretical values, so that the observed diffraction of radio waves from meteor trails obeys optical laws, and justifies the use of Fresnel's integrals for the calculation of velocities.

The time, T, to traverse a zone is determined from the measured number of pulses, p, and the known pulse-rate. Therefore the geocentric velocity, U, is given by

$$U = k\sqrt{R\lambda}/2T,$$

where k is the numerical value given in Table 1, appropriate to the particular zone selected.

The method has so far been applied to the Geminid meteor shower of December 11–13, 1947, and to the Quadrantid shower of January 3–4, 1948. The results are given in Fig. 2. The individual results for the Geminids are given in Table 3, which shows that meteors measured at widely different ranges give rise to constant mean values of $k\sqrt{R}/p$ as predicted by the above theory for the case where the velocity U is constant within a group of meteors.

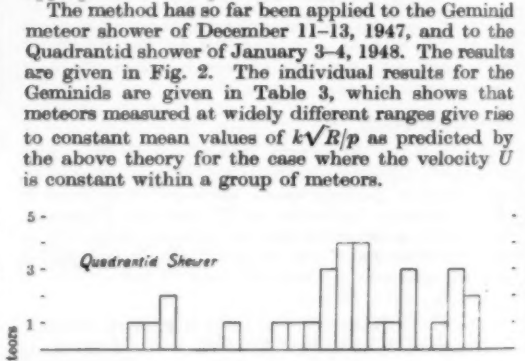


Fig. 2.

TABLE 3. GEMINID METEORS, DEC. 11–13, 1947

Range (km.)	$(k/p)_{mean} \times 10^{-5}$	$\frac{k}{p}\sqrt{R}$	Velocity (km./sec.)
460	7·85	1·68	33·7
470	7·90	1·71	34·3
170	13·60	1·77	35·6
370	8·95	1·72	34·6
370	8·84	1·69	34·1
420	8·32	1·71	34·2
400	8·74	1·75	35·1
440	7·90	1·66	33·2
220	11·32	1·68	33·8
490	8·30	1·83	36·9
400	8·07	1·61	32·4

The mean value for the geocentric velocity, U, of the Geminid meteors is 34·4 km./sec. (standard deviation 2·8 km./sec.), in excellent agreement with the velocity of 34·7 km./sec. obtained by Whipple[7] from photographic measurements of visible Geminid meteors.

The Quadrantid results indicate the existence of three velocity groups. The only existing measurements with which these results can be compared appear to be the visual estimates collected by Fisher[8], which gave Quadrantid velocities of 32–46 km./sec., with a mean value of 38 km./sec. The Quadrantid results also contain a group of meteors with a very low mean velocity of 22·4 ± 1·8 km./sec. These were obtained using a non-directional aerial system at the beginning of the shower, and may not be associated with the Quadrantid radiant.

In the present experiments the range was measured visually on a cathode ray tube display and the maximum range error is estimated as ± 20 km. This introduces a mean error of 5 per cent in the range measurements, or 2·5 per cent (± 0·8 km./sec.) in velocity.

Amplitude fluctuations with a frequency of the order of 15 per second have also been found and are being investigated.

This work was carried out at the Jodrell Bank Experimental Station of the University of Manchester. We are indebted to Mr. N. Herlofson for suggesting the possibility that Fresnel zones could be measured[6], and to Dr. A. C. B. Lovell for constant interest and advice.

C. D. ELLYETT
J. G. DAVIES

Physical Laboratories,
University,
Manchester.
Feb. 19.

[1] Hey, J. S., and Stewart, G. S., *Proc. Phys. Soc.*, **59**, 858 (1947).
[2] Prentice, J. P. M., Lovell, A. C. B., and Banwell, C. J., *Mon. Not. Roy. Ast. Soc.*, **107**, 155 (1947).
[3] Lovell, A. C. B., Banwell, C. J., and Clegg, J. A., *Mon. Not. Roy. Ast. Soc.*, **107**, 164 (1947).
[4] Lovell, A. C. B., *Nature*, **160**, 670 (1947).
[5] Hey, J. S., Parsons, S. J., and Stewart, G. S., *Mon. Not. Roy. Ast. Soc.*, **107**, 176 (1947).
[6] Herlofson, N., *Rep. Progress in Phys.*, **11**, 1948 (in the press).
[7] Whipple, F. L., *Proc. Amer. Philos. Soc.*, **91**, 189 (1947).
[8] Fisher, W., *Harvard College Observ. Circ.*, No. 346 (1930).

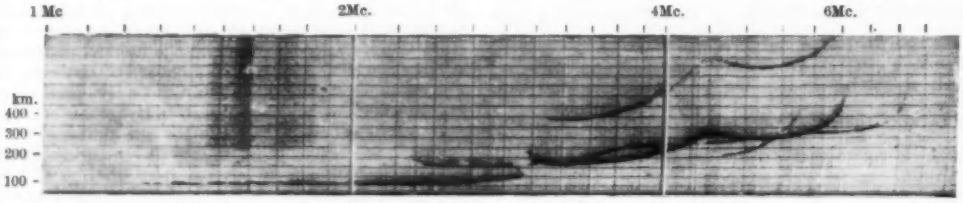
Triple Splitting of Ionospheric Rays

THE well-known theory of the ionosphere indicates the existence in polar regions of a third split in vertical incidence measurements of medium- and high-frequency radio wave reflexions from the ionosphere, its presence being due to the nearly vertical magnetic field of the earth. Its presence was first observed by Harang[1], and since then by others.

It was first seen in Canada in 1943 when the Churchill ionosphere station commenced operation. Since then the phenomenon has been observed frequently at other Canadian stations as well.

To date, observers have noted its presence only in the F_2 region; however, in Canada a complete trace is often seen extending from the E region through the F_1 region to the F_2 region.

The accompanying sample record was made with the National Research Council's automatic ionosphere recorder at The Pas, Manitoba (54·0° N., 101·0° W.). May 16, 1946, at 17.00 C.S.T. and illustrates some of the observed characteristics of the third split (z trace).



The following points may be noted:

(1) The z trace follows through from f^zE to f^zF_2.

(2) The down sweep on the left-hand side of the z trace indicates the presence of f^zE (2·3 Mc.), and on the original record there is evidence of retardation of the E region z trace to this point.

(3) $f^zF_2 = 5{\cdot}45$. $f^zFz - f^zF_2 = 1{\cdot}5$ Mc.
$f^oF_2 = 6{\cdot}10$. $f^zF_2 - F^oF_2 = 0{\cdot}85$ Mc.
$f^zF_2 = 6{\cdot}95$.

(4) The $F_1{}^z$ trace disappears at f^oE; this is a normal occurrence.

(5) Retardation at f^oF_1 is greater than at f^zF_1 and f^zF_1.

(6) The minimum virtual heights of the F region traces increase from z trace to o trace to x trace.

J. H. MEEK

Radio Propagation Laboratory,
Defence Research Board.
Jan. 22.

[1] Harang, L., *Terr. Mag. and Atmos. Elect.*, **41**, 143 (1936).

MR. GORDON NEWSTEAD, of Hobart, Tasmania, has observed a triple splitting of the rays reflected from the F region[1]. The occurrence of such triplets had already been observed in 1933, when they were described at a meeting of the Royal Society[2]. The signals were received on a polarimeter, so that the polarization of the triplets was known. These were always of the type of two ordinary rays and one extraordinary ray. The mechanism of the triplet was therefore known, and although no explanation was given in the paper, it had been discussed by Millington and myself.

If these triplets were due to the coupling between the ordinary and extraordinary rays, they would be

expected to have one extraordinary and two ordinary characteristics—as, in fact, they have. That such coupling exists is without doubt, so that the explanation that it is the direct cause of the triplets observed is, I think, correct.

The frequency of the occurrence of these triplets is small. We received only five in five months. At Hobart, thirty-nine cases in fifty thousand records have been obtained. This is rather greater than we observed, but the explanation is, I think, quite correct.

The photograph shown is a very clear instance of this triple splitting, which has also been observed by Harang[3].

T. L. Eckersley

Weatheroak, Danbury,
Essex.

[1] *Nature*, **161**, 312 (1948).
[2] *Proc. Roy. Soc.*, A, **141**, 710 (1933).
[3] Harang, *Terr. Mag. and Atmos. Elect.*, **41**, 160 (1936).

Blackett's Hypothesis of the Magnetic Field of Rotating Bodies

Prof. P. M. S. Blackett[1] has recently directed attention to the well-known, but forgotten, fact that the ratio of magnetic moment $\vec{P}$ and angular momentum $\vec{U}$ is roughly the same for the sun and for the earth and can be written in the form,

$$\vec{P} = -\beta \frac{G^{1/2}}{2c} \vec{U}. \quad . \quad . \quad . \quad (1)$$

Here G is the gravitational constant, c the velocity of light and β a dimensionless constant of the order of unity, which Blackett estimates to be 0·30 for the earth and 1·14 for the sun. Furthermore, from Babcock's measurements Blackett deduces the value $\beta = 1{\cdot}16$ for the star 78 Virginis, but since the mass, radius and angular velocity are all deduced statistically in this last case and the sign is unknown, only little weight can be attached to it.

Next, Blackett urges that (1) may be generally true for all rotating, electrically neutral bodies and thus give a clue to a possible connexion between electromagnetic and gravitational phenomena. Quite apart from the secular variation, the fact that $\vec{P}$ and $\vec{U}$ are not parallel either for the earth or for the sun, and the fact that an eccentric dipole field gives a better description of the main field of the earth than does a centered dipole field, the relation (1) meets with the following difficulties.

On the analogy with the magnetic field of moving electric charges, the magnetic field of a rotating neutral mass may be interpreted from the point of view of non-atomic field theory, that is, as a field property depending on the relative motion of the body and the observer, as was done in the previous theory of H. A. Wilson on the magnetic field created by the translational motion of neutral bodies. However, in this interpretation one would expect the magnetic field to be different in a co-ordinate system which follows the body in its rotation, that is, in which the body is at rest, and in one relative to which the body rotates, because the gravitational field is different in these two co-ordinate systems. Since the main magnetic field of the earth as measured on the earth itself is experimentally found to be the same as that measured in even the fastest moving aeroplanes, the main magnetic field of the earth could scarcely be explained on such lines. (Nevertheless, this hypothesis might, of course, be true, that is, give an additional magnetic field not detectable on the earth itself. In that case we would expect the magnetic field acting on cosmic ray particles, which do not partake in the rotation of the earth, to be different from that measured on the earth.) However, on general principles it is rather unlikely that in classical field theory there should exist a connexion between electromagnetic and gravitational phenomena such as (1), because the sign of $\vec{P}$, but not of $\vec{U}$, depends on the definition of plus and minus electric charge, and thus north and south magnetic pole, which definitions are quite arbitrary. The signs can only be defined in an unambiguous way from an atomic theory involving a knowledge of the atomic constitution of matter.

Consequently, if the relation (1) should be generally true, as conjectured by Blackett, it must be interpreted from an atomic point of view as meaning that the body itself is magnetized, that is, that a magnetic dipole moment density is induced in the body when rotated relative to the inertial co-ordinate system of the fixed stars. However, in that case, first one would expect (1) to contain not only classical constants such as G and c, but also both atomic constants and constants characteristic for the material of the body[2]. Secondly, it is difficult to imagine another atomic mechanism to give a relation like (1) than the gyromagnetic—which, however, gives a uniform magnetization, and thus for a sphere $P \propto M\omega \propto \frac{U}{R^2}$. (This form of magnetization is just an example of one which occurs for rotational but not for translational motion.) Thirdly, also in this case of a rotating electrically neutral mass the body would be associated not only with a magnetic field, but also with an electric field, as pointed out by Blackett in the case of translational motion. For from the Lorentz transformation it follows that each volume element carrying a magnetic dipole moment $d\vec{P}$ will show in a co-ordinate system relative to which the element moves with velocity $\vec{v}$ an electric dipole moment given by $\frac{1}{c}\vec{v} \times d\vec{P}$ (for $\frac{v^2}{c^2} \sim 0$). For example, a symmetric rotating body will thus be surrounded by an electric quadrupole field, and no rotating body can be surrounded by a purely magnetic field. (The influence on the motion of cosmic ray particles of this electric field which must surround the earth ought to be investigated more closely.)

We note that it may be possible experimentally to test Blackett's hypothesis (1) by the experiments of Barnett on the gyromagnetic magnetization (or perhaps by the experiment of Einstein and de Haas on the inverse effect of rotation by magnetization)[3]. For example, for a cylinder with radius R and density d and making ν rotations per second we get from Blackett's hypothesis an average magnetization of $\overline{I}_{Bl} = 7{\cdot}9 \times 10^{-15}\ \nu\ dR^2$, whereas the gyromagnetic effect gives a uniform magnetization $I_{gy} = 3{\cdot}6 \times 10^{-7}\ \chi\nu$ (χ is the susceptibility of the body). Thus the two magnetizations are of the same magnitude if $\frac{dR^2}{\chi} = 5 \times 10^7$. Taking, for example, a paramagnetic material like aluminium for which $\chi = 1{\cdot}7 \times 10^{-6}$ and $d = 2{\cdot}7$, this is the case already

for $R \sim 5$ cm. Before such experiments are performed with a positive result we think it is more probable that if (1) is not merely accidental, it may be due to a common origin of $\vec{P}$ and $\vec{U}$, since it is possible that their values are determined already by the creation process of the earth and the sun.

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[1] Blackett, *Nature*, **159**, 658 (1947).
[2] Cf. also the theory of Pauli, *Ann. Phys.*, **18**, 337 (1933), especially p. 372 where $G^{1/2}/c$ occurs in connexion with $\hbar$.
[3] See, for example, Barnett, *Rev. Mod. Phys.*, **7**, 129 (1935).

IN his paper on the magnetic field of rotating bodies, P. M. S. Blackett has shown[1] that the relation $(P/U)_1$ between magnetic moment P and angular moment U of a rotating body seems to be independent of its size and constitution (about $0{\cdot}95 \times 10^{-15}$ E.M.U.); he also tried to explain the physical significance of this constant. He based his considerations on the well-known equation for the Bohr magneton, which is written

$$\left(\frac{P}{U}\right)_2 = \frac{e}{2mc} = 0{\cdot}88 \times 10^7 \ [\text{cm.}^{1/2}\,\text{gm.}^{-1/2}]. \quad (1)$$

Blackett points out that the empirically determined relation

$$\frac{(P/U)_1}{(P/U)_2} = 1{\cdot}08 \times 10^{-22}$$

corresponds in order of magnitude with the well-known non-dimensional equation

$$G^{1/2}\,\frac{m}{e} = 4{\cdot}90 \times 10^{-22} \ [\text{E.S.U.}] \quad (2)$$

(G is gravitational constant). For this reason, the new relationship

$$\left(\frac{P}{U}\right)_1 = G^{1/2}\,\frac{m}{e}\left(\frac{P}{U}\right)_2 \quad (3)$$

was introduced. By putting (1) in (3) he was able to show that

$$\frac{P}{U} = \frac{G^{1/2}}{2c} \quad (4)$$

represents the magnetic moment of a rotating body as a function on one hand of the angular moment, and on the other of the gravitational constant and the velocity of light.

In its present form, however, equation 4 is, from the physical point of view, not complete. The term c in that equation, for example, should not be identified with the velocity of light. This value is taken from equation 1, where it is only used to transform the value of e, quoted in electrostatic units, into electromagnetic units. Therefore equation 1 should be written in a more general manner, independent of any system of units, as

$$\left(\frac{P}{U/2}\right)_2 = \frac{2P}{\hbar/2\pi} = \mu\,\frac{e}{m} \quad (1a)$$

(where μ is permeability of a vacuum, $\hbar$ is Planck's constant; the number 2 originates from the definition of the angular momentum and belongs therefore to U). Only in this form is equation 1 correct with reference to any system of dimensions.

Equation 2 also does not contain all the necessary physical quantities to make it correct dimensionally. The equation should be completed and then read as

$$\frac{\varepsilon^{1/2}\,G^{1/2}\,m}{e} = 4{\cdot}90 \times 10^{-22} \quad (2a)$$

(where ε is the dielectric constant of the vacuum).

It becomes obvious that the above equation is now a non-dimensional one if the reciprocal value of G, namely, $1/G = \gamma$, is introduced; the result is the symmetrical equation

$$\frac{\varepsilon^{1/2}}{\gamma^{1/2}}\,\frac{m}{e} = 4{\cdot}90 \times 10^{-22}. \quad (2b)$$

Blackett's equation 3 must then be written as

$$\left(\frac{P}{U}\right)_1 = \frac{m}{e}\sqrt{\frac{\varepsilon}{\gamma}}\left(\frac{P}{U}\right)_2. \quad (3a)$$

If (1a) is put in (3a), then finally equation 4 will be replaced by

$$\frac{P}{U/2} = \mu\sqrt{\frac{\varepsilon}{\gamma}}. \quad (4a)$$

This equation is numerically correct not only in the usual non-rational electrostatic system but also in the non-rational electromagnetic system of units, where the following relations are valid:

	E.S.U.	E.M.U.
$\varepsilon =$	1	$\frac{1}{9} \times 10^{-20}$
$\mu =$	$\frac{1}{9} \times 10^{-20}$	1
$\gamma =$	$1{\cdot}5 \times 10^7$	

The removal of the factor c from equation 4 has led now to equation 4a, which is correct in any system of units and dimensions and shows that the new relation ε/γ (of the dielectric constant to the gravitational constant) may be one of the decisive relations concerned in this matter.

It is furthermore easy to understand that the permeability μ must play an important part in (4a), as we are dealing here with fundamental *magnetic* questions; indeed, it would be surprising if this physical quantity were not involved when dealing with such a matter.

In any event, the fact that the general electric properties of matter are decisive for the formation of the steady magnetic field of rotating massive bodies is best shown by equations 4a and 1a in the form

$$P = \frac{U}{2}\,\mu\sqrt{\frac{\varepsilon}{\gamma}} = \frac{U}{2}\,\mu\,\frac{e}{m}. \quad (5)$$

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Jan. 11.

[1] Blackett, *Nature*, **159**, 658 (1947).

Spontaneous Waves in Discharge Tubes and in the Solar Atmosphere

A THEORETICAL study has been made of the plane electromagnetic waves which can exist in a strongly ionized gas when a constant electric field $\mathbf{E}_0$ and a constant magnetic field $\mathbf{H}_0$ are both present. As the results of this work appear to be of general interest, a brief account of them is given here.

It is found that in general for waves of a given frequency the medium is octuply refracting and that under certain conditions the absorption of the medium is negative, that is, the medium acts as an amplifier

for one or more of the types of wave which can travel through it with the given frequency.

It is found similarly that in the medium there are eight possible types of wave with a given wave-length and three possible types with a given phase-velocity, and that under certain conditions one or more of these types can exist with the property that at any given place the *amplitude of the wave grows with the lapse of time* up to one of two possible limits.

The presence of a constant electric field is essential for the existence of growing waves. The addition of a constant magnetic field increases the possibility that spatially growing or secularly growing waves can exist in the medium and also increases the range of their frequencies.

These results of the theory can be applied to the ionized gas in a discharge tube or in the solar atmosphere.

In different parts of the tube the electron and ion densities and the electric field can vary in magnitude considerably. It is therefore possible for conditions to exist in which waves can grow from any random fluctuation of these magnitudes. The phase-velocities and the corresponding frequencies of these growing waves will depend on the form of this initial fluctuation as expressed by means of a Fourier integral. In this way electric noise can arise over a large range of frequencies. The addition of a magnetic field serves to increase these possibilities. The existence of boundaries in a discharge tube will under certain conditions favour the development of certain waves into steady types each with a definite wave-length and its associated frequency.

The abnormal solar noise which has been much studied in recent years can be explained in a similar way if we postulate that constant (or slowly varying) electric fields can arise in the solar atmosphere, and that large local transient changes in this atmosphere can occur from time to time. There is little doubt that both these conditions do occur on the sun.

A similar explanation can be advanced for cosmic noise if we regard this noise as originating in the ionized atmospheres of stars, especially of those which are magnetic.

A detailed account of this work will be published elsewhere.

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Method of Steepest Descents: Improved Formula for X-Ray Analysis

Booth[1] uses two formulæ as a starting point of the method of steepest descents, applied to X-ray crystal structure analysis:

$$R_1 = \Sigma \left| \, |F_o| - |F_c| \, \right| = \text{minimum}, \qquad (1)$$

$$R_2 = \Sigma \, (F_o^2 - F_c^2)^2 = \text{minimum}. \qquad (2)$$

According to the method of least squares, a formula of the form Σ (error)^2 = minimum is correct only when all the observations have the same weight and when the errors follow Gauss's law. As the intensities are $I \sim F_o^2$, formula (2) assumes equal weights of all the measured intensities. This might hold for initial steps of approximation; but for final steps the average errors are proportional to the intensities and the errors do not obey Gauss's law. However, when logarithms of intensities are plotted, the average errors in the logarithms are constant and Gauss's law is obeyed. It follows thus that, at the later stages,

$$R_3 = \Sigma \, (\log I_o - \log I_c)^2 \qquad (3)$$

should be minimized rather than (1) or (2). Zero observed intensities can be avoided by substitution in (3) for I_o the threshold observed intensities I_t, except when $I_c < I_t$; then the error should be put equal to zero. The formula (3) should be used only at a stage of approximation when all the signs of F_c remain constant.

The change ε_{rj} of the atomic co-ordinates x_{rj} in any one step can be regarded as a vector ε in the $3N$-dimensional space; its direction is given by the direction cosines grad R/| grad R | and its magnitude by | ε | = s. Writing | grad R | = D, we have

$$\varepsilon = \frac{s \, \text{grad} \, R}{D}. \qquad (4)$$

Along the normal, R is a function of s only; we can thus write:

$$R(s) = R(0) + Ds + \frac{1}{2!} D_2 s^2 + \frac{1}{3!} D_3 s^3 + \ldots, \qquad (5)$$

where D, D_2, D_3, etc., are the derivatives of R along the normal at the point $s = 0$.

Neglecting higher power terms in s than the second,

$$dR/ds = D + D_2 s, \qquad (6)$$

so that for a minimum of R, the value of s is $s_m = -D/D_2$. By substituting this in (4)

$$\varepsilon_m = -(\text{grad} \, R)/D_2, \qquad (7)$$

which is equivalent to the first formula of Booth. Neglecting higher-power terms in s than the second, (5) can be written as

$$R(s) = R(m) - \frac{1}{2} D(s - s_m)^2/s_m. \qquad (8)$$

If we assume $R(m) = 0$, or negligible compared with $R(0)$, we have $s_m = -2R/D$. Substituting this in (4),

$$\varepsilon = -2R \, \text{grad} \, R/(\text{grad} \, R)^2, \qquad (9)$$

which is the second formula of Booth, and which contains first partial derivatives only. When, however, $R(m)$ cannot be neglected, then (9) gives too large a shift. When x_{rj} are near their optimum values, ε calculated from (9) may be much larger than ε_m, and R may even increase; Booth then recommends the use of (7).

A method has been devised by which the laborious calculation of D_2, which contains many second partial derivatives of R, is obviated even near optimum values of x_{rj}, resulting in a great saving of time. According to this method, ε is first calculated from (9) even when x_{rj} are near their optimum values and R increases. The shift calculated is thus $s_1 = -2R/D$. The value of $R(s_1) = R(1)$ is calculated from (3). However, now we know two points $R(0)$, $R(1)$ and a tangent D at $s = 0$ of the curve $R(s)$. This allows us to calculate from the three conditions the value of D_2:

$$D_2 = 2(R(1) + R(0))/s_1^2,$$

and thus $s_m = s_2$ is given by

$$s_2 = -D/D_2 = R(0) \, s_1/(R(0) + R(1)). \qquad (10)$$

At this point

$$R(m) = s_2 R(1)/s_1. \qquad (11)$$

Using now s_2 instead of s_1, we calculate $R(2)$ from (3) and compare it with $R(m)$ calculated from (11). If $R(2) = R(m)$, our assumption of higher derivatives being zero or negligible was justified. If the effect of higher derivatives is not negligible, the process can be repeated until minimum is reached.

If the observed F_o are not on an absolute scale, they can be adjusted by multiplying them by a constant K, given by

$$\log K = -\frac{1}{N} \Sigma (\log F_o - \log F_c). \qquad (12)$$

This adjustment of the scale can be repeated after each approximation, as the changes of the co-ordinates may also affect the value of K.

We have successfully applied these methods to the three-dimensional refinement of parameters of a crystal of potassium caprate, a preliminary report of which was given by Vand, Lomer and Lang[1], and to the structure of lauric acid.

I wish to thank Messrs. A. Aitken, W. M. Morley and Miss B. Edkins for testing the method, and the directors of Lever Brothers and Unilever, Ltd., for permission to publish this note.

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[1] Booth, A. D., *Nature*, **160**, 196 (1947).
[2] Vand, V., Lomer, T. R., and Lang, A., *Nature*, **159**, 507 (1947).

Surface Resistance of Metal Films at a Frequency of 24,000 Mc./s.

THE reflexion, transmission and absorption coefficients (R, T, A) of a thin metal film can be expressed in terms of its surface resistance S, if the frequency is low enough for classical electromagnetic theory to apply. Then measurements of R, T, or A yield theoretical values of S which can be compared with the value (S_o) obtained from D.C. measurements on the film. Experiments of this type have been carried out[1-3] at infra-red wave-lengths (6–110 μ); but while a measure of agreement has been obtained, the anomalies suggest that dispersion occurs at these short wave-lengths. With the view of effecting a similar comparison between S and S_o at centimetre wave-lengths, the theory has been investigated afresh[4] to include the effect of multiple reflexions occurring in the film and its support, and has been extended to find the resonance condition for a cylindrical cavity resonator operating in the H_{01} mode, when it is loaded with a film of metal carried by a low-loss support travelling on the plunger. The theoretical value of the surface resistance is then given by the expression

$$S = \frac{120\pi\lambda_1}{\lambda\left[1 + \cot\frac{2\pi l'_1}{\lambda_1}\left\{2\cot\frac{4\pi l_1}{\lambda_1} - \cot\frac{2\pi l'_1}{\lambda_1}\right\}\right]^{1/2}},$$

where λ is the wave-length in air, λ_1 that in the empty resonator, while l_1 and l'_1 are the resonant lengths of air space in front of the support in the presence and absence respectively of the film. In practice, λ is calculated from λ_1 and a resonator dimension, while l'_1 may either be measured directly, or calculated from the thickness and permittivity of the film support.

Extensive measurements have been made at a frequency of 24,000 Mc./s. to test this relation and certain other theoretical predictions. For this purpose films of chromium, gold, aluminium, silver, copper and nickel of uniform thickness have been prepared by evaporation *in vacuo* on silica disks, some of which have been optically flat. Silica was chosen as the material for the film support because of its extremely small loss, and its permittivity at this frequency has been evaluated as $3{\cdot}8 \pm 0{\cdot}001$. After measuring S, the value of S_o has been determined in each case by evaporating thick silver contacts on to the film and measuring the resistance of a circular annulus by bridge and other methods. The film thicknesses investigated have lain in the range 5–300 A.; for most metals this covers a range of values for S_o lying between infinity and a few ohms/cm.[5].

Throughout this range the qualitative agreement between S and S_o has been excellent. Thus if $S_o = \infty$, the A.C. measurement always yields a value of $l_1 = l'_1$, so that $S = \infty$. Again, a low value of S_o always corresponds to a low value of S, that is, $l_1 \sim \lambda_1/2$. Films with intermediate values of S give values of l_1 lying between these extreme limits, and the phase shift due to the film may be large. However, the high absorption of such films lowers the effective Q of the resonator, and the broadening in the response renders the precise determination of l_1 difficult. Nevertheless, the quantitative agreement between S and S_o over the entire range of values is good. It is found that S is always less than S_o, the ratio S_o/S generally lying between 1 and 2. A part of this small discrepancy can be attributed with certainty to the effect of the evaporated contacts on the film, since different contacts give slightly different values of S_o. Aggregation in the film or surface oxidation occurring on exposure of the film to air would also contribute to the higher value of S_o. Finally, the same agreement between S and S_o has been found for films of metal contaminated with oxide, suggesting that the agreement is of a statistical nature.

Since any wave trapped in the resonator is partially reflected and transmitted by the film several times, the expression given for S represents a more stringent test of the theory than any of the expressions for R, T, A used in the infra-red, which depend on a single encounter between the wave and the film. The agreement obtained experimentally between S and S_o must therefore be regarded as very satisfactory, indicating that the theory and underlying assumptions are valid and that no dispersion occurs in the metal at this frequency. The resonator method can thus be used to study other film properties connected with the electrical conductivity, for which purpose it has the advantage that no contacts to the film are required.

This work was partly carried out at the Clarendon Laboratory, Oxford; a fuller account will appear elsewhere.

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Dec. 20.

[1] Murmann, H., *Z. Phys.*, **54**, 741 (1929).
[2] Barnes and Czerny, *Phys. Rev.*, **38**, 338 (1931).
[3] Woltersdorff, W., *Z. Phys.*, **91**, 230 (1934).
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A Large Field Compensator for Measurement of Birefringence

A FROZEN stress compensator using a *C R* 39 resin strip, such as is described by Messrs. P. E. Jellyman and A. J. Milne in *Nature* of March 27, p. 477, was constructed and used at the Naval Construction Research Establishment, Rosyth, in 1944. It was briefly described in a paper read to the Edinburgh and District Association of the Institution of Civil Engineers in November 1944.

The instrument could not be made to be as stable as a quartz wedge compensator, but fulfilled a useful purpose while the delivery of a Soleil-Babinet compensator was awaited.

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The Swimming of Dolphins

DOLPHINS in the Gulf of Panama have been seen moving through the sea at a speed of ten knots, their entire bodies showing no apparent swimming motion. This performance was confined, in my observations, to the area immediately forward of the stem (prow) of a sea-going tug and to an estimated depth of one metre or less. Elsewhere near the bow, vertical oscillations of dolphins' tails were readily timed with a stop watch.

When this 'motionless' swimming was first noticed, the animals were in the normal swimming position. In this position it was difficult to be sure that vertical motions of their tail surfaces were not occurring, since the direction of such motions would be nearly parallel with the line of sight of the observer. However, on several occasions dolphins were seen to turn on their sides during the 'motionless' swimming in such a position that their usual swimming motions would have been normal to the line of sight. No motion was visible in these animals, which were clearly seen just below the surface of the water. One animal remained on its side in this manner for 59 sec., which represented a distance, at 5·15 m./sec. (10 knots), of 304 metres. At this time dolphins swimming near by used 1·9 tail oscillations per second in keeping pace with the vessel.

These 'motionless' dolphins seemed to be riding the bow wave (that is, falling down the inclined surface). However, if dolphins are equal in weight to the weight of the water they displace, wave riding is not possible. No data have been found concerning their density. Kellogg[1] says, however, that dolphins usually sink when shot. Is it possible that they are dense enough to fall down the advancing slope of the bow wave, having achieved terminal velocity initially by swimming? A low over-all resistance to motion through the water would seem to be required. Gray[2] has indicated that the work done by dolphin muscle in producing a speed of 10 m./sec. is comparable to the work of other mammalian muscle tissue, if laminar flow is assumed around the dolphin. With turbulent flow, Gray found that the work done by dolphin muscle at 10 m./sec. would be about seven times the work of other mammalian muscle. If a laminar regime exists at a speed of 5 m./sec., perhaps the over-all resistance to the motion of a dolphin is low enough to allow an animal, of sufficient negative buoyancy, to fall down the inclined water surface of a bow wave or other waves.

It may be thought that the dolphins were gaining a forward thrust by placing their tails against the ship's stem. Dolphins have been seen with their tails in momentary contact with the hull, but in the above observations of 'motionless' swimming the animals were clearly forward of the vessel.

Shoulejkin[3] suggests that the speed of motion of the dolphin's tail may be very rapid. Dolphins seen 'motionless' in the bow wave may have been using rapid tail oscillations of very small amplitude, causing them to appear to be motionless. If such swimming motions were in fact occurring, it is curious that the use of this propulsive technique should be confined to the immediate vicinity of the bow, while other dolphins a few metres away always used a large amplitude vertical tail motion with a period of about half a second (at 10 knots).

I would like to know whether other observers have seen this 'motionless' swimming, and what explanations may have been given.

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Woods Hole Oceanographic Institution,
Mass. Jan. 30.

[1] Kellogg, Remington (personal communication), U.S. National Museum, Washington, D.C., 1948.
[2] Gray, J., "Studies in Animal Locomotion. VI. The Propulsive Powers of the Dolphin", *J. Exp. Biol.*, **13**, 192 (1936).
[3] Shoulejkin, W. W., "Physics of the Sea", Publication Acad. Sci U.S.S.R., Moscow-Leningrad, see pp. 715–724 (1941).

Control of Cattle Trypanosomiasis

MRS. ELSPETH HUXLEY suggested in a letter in *The Times* (Sept. 16, 1947) that possibly cattle trypanosomiasis might come to be controlled by immunological methods. If this were achieved, resettlement of tsetse-infested land could be accomplished without such undesirable features as the destruction of plant and animal life. On the assumption that man and tsetse flies are ecologically incompatible, resettlement must cause recession of the 'fly'. Domestic stock are, therefore, the key to the problem, since tribal customs in East Africa are such that a threat to the stock constitutes a threat to the community. Resettlement is only possible if stock can be enabled to survive in 'fly'-infested areas.

There is a certain amount of evidence that, with intensified research, means could be found to 'salt' cattle, so as to enable this to be accomplished.

Survival of game in tsetse-fly areas. Carmichael at Entebbe (unpublished data) found that the young of game animals, notably duiker and sitatungu, which abound in tsetse-fly areas, are as susceptible as domestic animals to artificial infection with *T. congolense*. It follows that the immunity of some game animals at any rate is acquired and not hereditary.

Survival of cattle in tsetse-fly areas. Cattle in many parts survive in tsetse-fly areas, as reported from Kenya, Southern Rhodesia and the Gold Coast. Such cattle are usually deliberately exposed by the owners to tsetse-fly attack from birth onwards.

Immunity of cattle to T. congolense. Young calves usually recover from infection with *T. congolense*[1–3]. Taliaferro[4] has demonstrated solid immunity to *T. lewisi* in rats following recovery; the same has been demonstrated by Fiennes[5] in the case of cattle, but only to the infecting strain.

Laveran and Mesnil[6], in re-infection experiments with goats, could only demonstrate four strains of *T. congolense*.

Control by drug therapy. Trypanosomiasis of cattle can be successfully controlled by drug therapy. Observations on the cattle of a European farmer who has established a herd of nearly a thousand cattle in a tsetse-infested area appear to show that drug control over a period of years will lead to the development of stock which become somewhat resistant to, or tolerant of, the parasite.

Development of resistance in cattle by artificial means. In the case of twenty cattle, some infected with *T. congolense* and some with *T. vivax*, a fatal course has been converted to a benign one by means of subcurative dosage with phenanthridinium compounds. This work is not yet complete, but it can be said that all the cattle are healthy and some are surviving after carrying the trypanosome for more than fourteen months. One calf was born to an infected dam and was infected at birth. The calf has never been sick, and at six months old is thriving. It remains to be seen whether the parasite will eventually be eliminated, and if so what degree of immunity will be developed.

Control of trypanosomiasis in cattle. The evidence given is scanty, because the pathology and immunology of the trypanosomiases have been virtually neglected for the past thirty years. Nevertheless, it may suggest that an attack on these lines might bring the most rational solution to the tsetse-fly problem, by enabling breeding herds to be established in 'fly' areas and by resettlement with human populations and consequent elimination of 'fly' by natural ecological means.

What has been written is a simplification of the problem, inevitable from lack of space.

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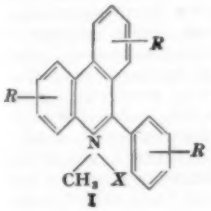
Veterinary Research Laboratory,
East African Veterinary Research Organisation,
P.O. Kabete. March 17.

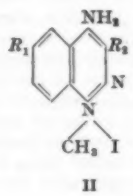
[1] Livingstone, "Missionary Travels in South Africa".
[2] Van Saceghem, R., *Bull. Soc. Path. exot.*, **27**, 170 (1934); *Bull. agric. Congo Belge*, 47 (1936); *Bull. Soc. Path. exot.*, **31**, 296 (1938).
[3] Fiennes, R. N. T.-W.-, Jones, E. R., and Laws, S. G., *J. Comp. Path. and Therap.*, **58**, 1 (1946).
[4] Taliaferro, W. H., "The Immunology of Parasitic Infections" (London, 1930).
[5] Fiennes, R. N. T.-W.-, *Vet. Rec.*, **59**, 291 (1947).
[6] Laveran, A., and Mesnil, F., *C.R. Acad. Sci., Paris*, **140**, 831 (1905).

Cinnoline Derivatives as Chemotherapeutic Agents for *Trypanosoma congolense* Infections

The most important disease of cattle throughout tropical Africa is that due to infection with *Trypanosoma congolense*, the cause, both directly and indirectly, of a vast amount of impoverishment. The most effective chemotherapeutic agents for this disease yet described in the literature are phenanthridinium compounds[1] having the general structure (I), in which two of the substituents are amino-groups and the third is a hydrogen atom.



I



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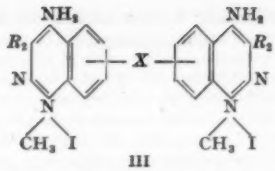


III

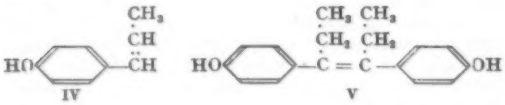
In view of the somewhat complex nature of such molecules, and of the difficulty of introducing amino-groups into any selected combination of positions, we have sought to ascertain whether trypanocidal activity is retained in simplifications of the phenanthridinium molecule, and have synthesized quaternary salts of a variety of mono- and di-amino-cinnolines, -quinazolines and -quinolines. In contrast to the highly active phenanthridinium compounds, our bicyclic heterocyclic quaternary salts have little or no trypanocidal action, and a possible explanation of this loss of activity is that the molecular weights of the cations of these bicyclic salts may be below the minimum necessary for activity.

Two of the compounds prepared during this investigation were 4 : 6-diamino-1-methylcinnolinium iodide (II; $R_1 = NH_2$; $R_2 = H$), m.p. 273–274° (found: C, 35·6; H, 3·7; N, 18·5; I, 42·2; $C_9H_{11}N_4I$ requires C, 35·75; H, 3·7; N, 18·5; I, 42·05 per cent), and its 3-methyl analogue (II; $R_1 = NH_2$; $R_2 = Me$), m.p. 283–284° (decomp.) (found: C, 36·0; H, 4·55; N, 16·8; $C_{10}H_{13}N_4I,H_2O$ requires C, 35·9; H, 4·5; N, 16·75 per cent). The constitutions of these compounds were established by the synthesis of each of them by two different procedures, and both these diamines were inactive in the pure state. However, the crude reduction products of the corresponding 6-nitro-salts (II; $R_1 = NO_2$; $R_2 = H$ and Me) (which were intermediates in one of the methods of synthesis) showed definite activity; the trypanocidal power varied considerably according to the conditions used for reduction, the most favourable result being a chemotherapeutic index of about 2 against *T. congolense* in mice (maximum tolerated dose about 4·5 mgm., intraperitoneally; minimum curative dose about 2·25 mgm. per 20 gm. body weight) obtained with a crude reduction product of II ($R_1 = NO_2$; $R_2 = Me$). Tested by the same technique, the two best-known phenanthridinium compounds, 'dimidium bromide' ('1553') and 'phenidium chloride' ('897') gave indices of about 15 and 3, respectively.

The observed trypanocidal activity is seemingly due to the incidence of side-reactions accompanying the conversion of the nitro- to the amino-quaternary salts; and, assuming that the same side-reaction is responsible for the development of activity in each of the two cases, the active components may possibly be the azo-compounds (III; $X = 6 : 6'—N=N$). On grounds of analogy, also, there is some reason for anticipating that structures such as (III) may be active, because one of the striking features of many non-arsenical trypanocidal compounds is that they are symmetrical molecules containing two identically constructed cyclic units (for example, diamidines, trypan red, suramin, surfen C, and Bayer 7602 Ac).

Our work is being continued along lines suggested by these observations. If our anticipations prove to be correct, this would indicate the desirability of synthesizing and examining a series of compounds of type (III), with variations in the linkage X as well as in the nature of the two quaternized heterocyclic units.

The steps leading to the finding of trypanocidal activity in compounds of type (III) would provide an interesting parallel to the course of events in quite a different field, that of synthetic sex hormones. The sequence leading to the discovery of œstrogenic activity in symmetrical compounds of the type of stilbœstrol (V) consisted in exploring simplifications of the naturally occurring *cyclo*pentenophenanthrene type of compound, followed by the demonstration of activity in crude preparations of anol (IV); purified preparations of (IV) were, however, found to be inactive, and the activity of the earlier crude preparations was then shown to be due to their contamination by (V)[2,3,4].



IV V

This work was supported by grants from the Medical Research Council and Messrs. May and Baker, Ltd.

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[1] First described by Browning, Morgan, Robb and Walls, *J. Path. Bact.*, **46**, 203 (1938); later work reviewed by Walls, *J. Soc. Chem. Ind.*, **66**, 182 (1947).
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Effect of Under-nutrition in Man on Hepatic Structure and Function

During August 1946 investigations were carried out on twenty-one civilian citizens of Wuppertal, an industrial German city south of Essen. For at least three months the official rations had not provided more than 35 gm. of protein, 15 gm. of fat and 176 gm. of carbohydrate a day, a total of 1,050 calories. Most of the subjects had been on short commons for twelve months. They were all under-nourished and had lost 6–46 per cent of their body weights. All stated that they had had nutritional œdema, and in sixteen this was clinically detectable. There was nothing in their clinical histories or examinations to suggest hepatic dysfunction. Their livers were not enlarged and no examples of gynecomastia, spider nævi or palmer hyperæmia were encountered.

Liver tissue was obtained from each subject by aspiration biopsy[1]. Histologically this tissue was generally normal, and there were no signs of necrosis, cirrhosis or fatty change. The liver cells sometimes contained considerable amounts of iron and chromolipoid pigment. Diminished blood volumes and low concentrations of hæmoglobin were found in these under-nourished subjects. There was, therefore, a withdrawal of hæmoglobin from the circulation with the liberation of much iron. Moreover, muscle myoglobin, released as muscles waste, may have provided further free iron. Iron in excess of immediate requirements cannot be excreted to any extent[2], and is stored in the liver. The hepatic siderosis observed in these subjects was never of the same extent or distribution as that reported in malnutrition in South Africa[3]. 'Ceroid' pigment was not present in the liver.

The urinary urobilinogen was often increased, and the fæcal urobilinogen diminished. The serum total bilirubin was within normal limits, and the bromsulphthalein excretion test gave normal results. Hepatic glycogen estimated quantitatively, fasting blood sugar concentration, oral glucose tolerance, adrenalin tolerance, and insulin sensitivity tests were all normal. Alkaline phosphatase in the liver was normal both in amount and in histological distribution. Serum alkaline phosphatase was also within normal limits.

In fourteen of the subjects the serum taken in the recumbent position contained a concentration of less than 6·0 gm. of protein/100 ml. The serum colloidal gold reaction was usually negative. The concentration of total serum cholesterol was often low. The percentage of the total cholesterol in ester form was also low. The intravenous hippuric acid synthesis test gave normal results.

The subjects had been living for about a year on a diet the protein content of which was low and mainly of vegetable origin. The intake of lipotropic compounds (which are mainly in and associated with animal protein) must have been diminished. We have failed, however, to demonstrate the hepatic necrosis, cirrhosis or fatty change produced in experimental animals by low dietary protein or a deficiency of lipotropic compounds. Correlation of our results with recent reports of malnutrition in the Far East and elsewhere, and in experimental animals, is extremely difficult. The present report refers only to the effects of under-nutrition on one group of Europeans in one town in Germany, at one particular time, namely, August 1946.

The detailed results of this work will be given in a Medical Research Council Special Report now in preparation.

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Isolation of Stilbœstrol Monoglucuronide from Human Urine

In a recent letter[1] in *Nature*, Dr. A. E. Wilder Smith reports that he finds, by indirect methods, that about 50 per cent of stilbœstrol administered to human beings is excreted as a monoglucuronide. He was, however, unable to isolate this conjugate from the urine of patients treated with the drug. Although stilbœstrol monoglucuronide has been isolated[2,3] from the urine of rabbits receiving relatively large doses of stilbœstrol, it has never been isolated from human urine owing to the small doses normally used. We have now succeeded in isolating a glucuronide of stilbœstrol from human urine and proved it to be identical with that obtained from rabbit urine.

Through the courtesy of Prof. T. N. A. Jeffcoate, we have been able to obtain urine from two women immediately after parturition, who had received, in 24 hours, five 4-hourly doses of 20 mgm. of stilbœstrol. From this urine we were able to isolate the benzylamine salt of stilbœstrol monoglucuronide in a pure crystalline state. This salt had melting point and mixed melting point 223° C. and showed $[\alpha]_D^{20} = -55°$ ($c = 0{\cdot}2$ in 50 per cent aqueous acetone) and was identical with a sample (m.p. 223° C. and $[\alpha]_D^{20} = -55{\cdot}3°$ (in 50 per cent aqueous acetone)) which we had previously[2] prepared from pure stilbœstrol monoglucuronide isolated from rabbit urine. The yield of benzylamine salt corresponded to 35 per cent of the stilbœstrol administered. Small amounts of free stilbœstrol were also detected in the urine.

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Preparation of Œstrogens from Urine by Application of High Temperatures

Œstrogenic substances are usually extracted from the urine of pregnant women, pregnant mares or stallions with organic solvents not miscible in water. There are certain disadvantages inherent in this method: large extraction vessels are required; in view of the great bulk of the initial liquid containing the œstrogenic substances in low concentration and the relatively small total interface between the urine and the solvent, a relatively large volume of the latter has to be used; this in turn involves the use of a large distillation apparatus and a high fuel consumption for the evaporation of the solvent from the extract. Moreover, a high proportion of ballast substances which later require separation accompanies the œstrogenic substances in the extract.

We found the following process helpful for the concentration and preparation of œstrogens: evaporate the initial liquid until a sticky, gum-like residue is left; and heat the residue to a temperature not exceeding 245° C. for five minutes so as to carbonize the bulk of the ballast substances, while substantially preserving the œstrogenic substances.

Extracts of the carbonized mass with organic solvents contain the œstrogenic substances in rather high concentration, so that the evaporation is a step of only minor importance. Owing to the virtually complete destruction of the ballast substances by the heating, the dry residue remaining after the evaporation of the solvent already possesses a high degree of purity. It can, of course, be further purified by the known methods.

None of the usual œstrogenic substances, such as œstrone, œstradiol, œstriol, hippulin, equilin, equilinine, and the like, are destroyed by the procedure of heating.

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A Rapid Method for the Estimation of Pregnanediol

The presence in urine of pregnanediol can be detected easily and rapidly by the following procedure, elaborated in the course of recent investigations and based upon protection of pregnanediol by zinc dust during acid hydrolysis, thereby also preventing discoloration affecting the final colour reaction.

To 100 ml. of urine are added 1·5 gm. of zinc dust and the mixture is brought to the boiling point. Concentrated hydrochloric acid (10 ml.) is added and the mixture is boiled for five minutes. The flask is immersed in cold water, when the zinc dust settles rapidly; the supernatant fluid is then decanted on to a sand column. The zinc retained in the flask is washed successively with 25 ml. $N/1$ hydrochloric acid, 25 ml. $N/10$ hydrochloric acid and three lots of water, each 25 ml.

The washing fluids are also decanted on to the sand column after the zinc has settled. The sand column is dried by sucking hot air through it. The zinc dust retained in the flask is shaken up with about 20 ml. hot alcohol (95 per cent), and the hot extract is decanted on to the sand column. As an appreciable proportion of pregnanediol is retained by the zinc dust, the hot extraction has to be repeated three times. The alcohol is passed rapidly through the sand and the filtrate is evaporated to dryness. The residue is redissolved in 5 ml. alcohol (95 per cent), to which 20 ml. of $N/10$ aqueous caustic soda are added. After standing for one hour in the cold a precipitate forms, and this contains the pregnanediol fraction; it is collected on a fritted glass filter, washed with water and dried. About 10 ml. of hot alcohol are then slowly passed through the filter.

The filtrate may be used for the Gutterman colour reaction. For this purpose it is evaporated to dryness and the residue is dissolved in 5 ml. of concentrated sulphuric acid. In the presence of not less than 0·5 mgm. of pregnanediol per 100 ml. of urine a deep yellow or orange colour develops rapidly. In the absence of pregnanediol, the solution is pale yellow or colourless.

The method may be adapted to quantitative estimations by the use of larger quantities of urine and gravimetric methods. In a series of cases, 24- or 48-hour specimens of urine were divided into portions and pregnanediol was determined quantitatively both by Astwood and Jones' method and by the method described above, utilizing gravimetric and colorimetric procedures. Similarly, weighed samples of sodium pregnanediol glucuronidate were subjected to hydrolysis, pregnanediol being recovered by the two methods. It was found that the sand–zinc method gives yields of practically the same order as the Astwood–Jones method. The sand–zinc method is rapid and easy to carry out. It has been found useful in replacing the established but laborious methods in the diagnosis of pregnancy, impending miscarriage and other clinical conditions for which the detection of pregnanediol is required.

It is hoped to publish the work on which this method is based, along with some account of the cases to which it has been applied, in fuller detail elsewhere.

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Higher Fatty Acid Dehydrogenase of Mammalian Liver

An enzyme dehydrogenating higher fatty acids has been described by several workers, including Lang and Mayer[1] and Annau *et al.*[2]. Lang and Mayer showed that adenylic acid activated such a system in rat liver, while Annau *et al.* showed that hypoxanthine similarly activated a fatty acid dehydrogenase of ox liver.

In order to elucidate the mechanism of the dehydrogenation, the purification of the responsible enzyme system has been attempted, but without appreciable success. Some experimental results obtained during this work, however, may be not without interest.

After dialysis against distilled water, both the preparations previously described[1,2] have now been shown to require coenzyme I, or at any rate a factor present in 45 per cent pure preparations[3] of the coenzyme. The purine or nucleotide activator is also required. Previous workers have reported that the enzyme activity is lost after standing for three days at 0° C., but with added coenzyme I the activity has been demonstrated after dialysing for ten days at 0° C.

Requirement for coenzyme I and the effects of hypoxanthine and adenylic acid as activators

Expt.	Activator (0·25 μmole of each compound)	Coenzyme I (45%)	Reduction times (min). With lauric acid (t_1)	No lauric acid (t_2)	Dehydrog. activity = 100 $(1/t_1 - 1/t_2)$
1	—	1 mgm.	24	27	0·5
2	Hypoxanthine	〃	7·1	15	7·3
3	〃	none	>50	>50	—
4	Adenylic acid	1 mgm.	7·0	10	4
5	〃	none	>50	>50	—
6	Hypoxanthine and adenylic acid	1 mgm.	6·0	8·5	4·5

A convenient source of enzyme is the dialysed aqueous extract of acetone-dried rat liver (1 ml. ≡ 40 mgm. dry wt.). The reaction velocity is measured by the rate of anaerobic reduction of methylene blue at 38° C. The stopper of the Thunberg tube contains 0·2 ml. of 1 : 2,000 methylene blue, while the tube itself contains 1·0 ml. enzyme, 1·5 ml. 0·02 *M*-lauric or palmitic acid emulsion in 0·15 *M*-potassium phosphate, *p*H 7·5, 20 μgm. hypoxanthine or adenylic acid and 1 mgm. coenzyme I preparation in a total volume of 3·0 ml. A control tube is otherwise identical except for the omission of fatty acid. To ensure that the two tubes are comparable, the *p*H values are checked by the glass electrode after the reduction of the methylene blue.

Added diaphorase has not been found to be necessary, but, assuming that the dye is reduced by the coenzyme I—diaphorase hydrogen—carrying system, there is sufficient diaphorase activity in the enzyme preparation to account for the slow reduction observed.

Hypoxanthine is a better activator than an equivalent amount of adenylic acid, adenosine di- or triphosphate, or xanthine. Uric acid and allantoin are inactive. The effects of adenylic acid and hypoxanthine are not additive, and since Kalckar[4] has shown the formation of hypoxanthine from adenylic acid in a similar enzyme preparation, it is reasonable to suggest that there is but one dehydrogenase system activated by hypoxanthine or a closely related compound.

In several repetitions of the preparation described by Annau, the high but variable recorded activities could not be repeated, even after dialysis and the addition of coenzyme I and diaphorase.

The use of dyes of higher redox potential than methylene blue (for example, 2 : 6 dichlorophenol-indophenol and indophenol) did not affect the rate of decolorization.

The optimum *p*H is between 7·0 and 7·7. Kinetic measurements are not easy to interpret because of the relatively high 'blank'.

The enzyme system is soluble after prolonged dialysis against distilled water, and no activity is sedimentable on centrifuging at 10,000 × *g* for twenty minutes. 2×10^{-3} *M* sodium cyanide inhibits 40 per cent, while 3×10^{-4} *M* ammonium vanadate, 3×10^{-4} *M* chloracetophenone, 6×10^{-3} *M* hydroxylamine, 10^{-4} *M* oleic acid and 4×10^{-5} *M* silver nitrate inhibit completely.

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Enzymic Action of Viruses and Bacterial Products on Human Red Cells

Human red cells incubated with a broth culture filtrate of *V. choleræ* acquire three new properties: they become panagglutinable[1]; they are no longer agglutinated by viruses of the influenza group[2]; and in the case of rhesus-positive cells, they become agglutinable by the corresponding incomplete *Rh*-antibody[3]. The finding that the influenza and Newcastle disease viruses produce the same three reactions on red cells[3,4] has stimulated further study of this phenomenon.

Appropriate human red cells were incubated at 37° C. for an hour with both a suspension from agar culture and supernatant from centrifuged broth culture of a number of bacteria. After washing and resuspension, the red cells were tested for virus hæmagglutination with influenza *A* (*PR* 8), influenza *B* (Lee), swine influenza (Shope) and Newcastle disease virus (Doyle), and for panagglutination by mixing them with serum from the same donor. The *Rh* test was performed either with serum containing incomplete anti-*D* antibody diluted beyond its panagglutination titre, or by suspending cells sensitized with anti-*D* and washed, in the bacterial products.

A survey of more than sixty organisms showed that a number of bacterial species produce the active substance. Besides *V. choleræ*, potent preparations producing all three reactions have been obtained from *V. proteus* and pneumococcus irrespective of type or virulence. Other organisms, including one strain each of *Streptococcus* Group *D*, *Streptococcus viridans*, *Staphylococcus albus*, *aureus* and *citreus*, *B. subtilis*, *B. mycoides*, *Erysipelothrix rhusiopathiæ*, *Erysipelothrix monocytogenes* and *Salm. choleræ-suis*, either produce panagglutinability alone, or also weaken hæmagglutination by some viruses, but are without

appreciable effect on red cells sensitized with incomplete anti-*D* antibody. Both bacterial suspensions and broth supernatants bring about these changes, although to somewhat different extent with different organisms. The different behaviour of different bacteria may be due to minor differences in the range of their substrates, or may be merely quantitative, depending on the differing sensitivity of the three tests. If the latter assumption is true, then the panagglutination test appeared to be most sensitive, the virus test came next and the incomplete anti-*D* test the least sensitive.

A preparation of concentrated and semi-purified enzyme from *Cl. welchii* type *B*, capable of destroying blood group *O*, *A* and *B* substances, was kindly supplied by Dr. W. T. J. Morgan and was found to produce all three changes in human red cells. These changes in red cells can be completely prevented by the previous addition of blood group *O* substance, and less completely so by *A* substance, both prepared from human ovarian cyst and hereafter referred to as human *O* substance and human *A* substance respectively. The same preparation of enzyme also inactivates the 'Francis inhibitor'[5] present in human *O* substance. These results do not necessarily mean that the same enzyme which destroys the *O* activity is also responsible for the red cell changes and inactivation of 'Francis inhibitor'. According to Morgan[6], the blood group *O* enzyme resists heating at 56° C. for thirty minutes, whereas heating in the same circumstances completely destroyed the activity on red cells and on 'Francis inhibitor'.

The enzymic nature of the process seems to be amply established by accumulated evidence. Freidenreich[1], in a detailed study of the panagglutination phenomenon produced by *M* and *J* diphtheroids and *V. cholerœ*, concluded that the process is probably enzymic in nature. All these agents (cholera filtrate, *welchii* enzyme and viruses) are first adsorbed on to, and then released from, red cells, requiring an induction period which in the case of viruses can be studied by the visible agglutination and elution reactions. The active principles are either very thermolabile or moderately so. Thus, pneumococcus and cholera filtrates were greatly weakened after heating to 56° C. for half an hour, while the Newcastle disease virus and *welchii* enzyme were completely destroyed at this temperature. Red cells treated with heat-inactivated enzymes gave negative results by all three reactions.

Since the three reactions of red cells are produced by preparations derived from widely different sources, and since all three are simultaneously prevented by inactivation of the enzymes at a given temperature, it seems most probable that each preparation contains a single enzyme responsible for the production of all three reactions. This explanation is strengthened in the case of *welchii* enzyme by the observation that all three activities are inhibited by the presence of human *O* or *A* substance. Burnet, McCrea and Anderson[7] have reported that both cholera filtrate and influenza viruses destroy the 'Francis inhibitor' present in crude mucin and purified blood group *O* and *A* substances, without, however, altering the immunological specificity of *A* substance, which was the only one tested. The presence of 'Francis inhibitor' in human *O* substance, and to a much less extent in human *A* substance, has been confirmed. However, a mixture of blood group *A* and *O* substances purified from hog gastric mucin and containing comparable *O* activity to that of *O* substance from a human source has no 'Francis inhibitor' activity even at 0·1 per cent concentration.

I have also found that influenza *B* virus, Newcastle disease virus, cholera and pneumococcus filtrates, although capable of destroying the 'Francis inhibitor' property of human *O* substance, nevertheless have no significant effect on its immunological activity. Furthermore, their action on red cells is not inhibited by the presence of either human *O* or *A* substance. These findings seem to suggest that the blood group substances *per se*, as defined immunologically, are not the true virus receptor substance. A fuller report will appear elsewhere.

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Choleglobin Formation in the Erythrocyte

The pioneer researches of Lemberg and his co-workers[1] have provided a new approach to the problems of hæmoglobin breakdown and bile pigment formation. Using his methods, we have recently re-examined the question of the occurrence of the intermediate choleglobin in the intact erythrocyte.

To determine the quantity of choleglobin present, the pigment is disrupted by 66 per cent acetic acid to biliverdin, which is extracted with 5 per cent hydrochloric acid, and measured colorimetrically. During the acetic acid treatment, further oxidation of biliverdin to biliviolin was observed, but Lemberg was able to prevent this change by addition of 10 mgm. ascorbic acid as antioxidant. It appeared to us that this procedure might lead to error, since choleglobin is itself formed rapidly by coupled oxidation of ascorbic acid with oxyhæmoglobin.

In the present work this difficulty was avoided by carrying out the whole Lemberg procedure in an apparatus that could be completely evacuated or filled with an inert gas, so that all the reactions could be carried out in an oxygen-free atmosphere. In this way, the following side-reactions were inhibited: (1) formation of choleglobin from oxyhæmoglobin by coupled oxidation with intracorpuscular ascorbic acid or glutathione; (2) oxidation of biliverdin to biliviolin by atmospheric oxygen, or by active oxygen liberated by acid denaturation of oxyhæmoglobin; (3) conversion of choleglobin to 'green pigment'.

Lemberg and Legge[2] have observed that normal human red blood corpuscles contain 1–5 μgm. biliverdin per c.c. combined as choleglobin.

In our anærobic experiments no choleglobin could be detected in a series of twelve separate samples of normal human blood, nor in blood samples taken from patients suffering from pernicious anæmia, leukæmia, hæmolytic anæmias, hepatic and obstructive jaundice, or polycythæmia, with the following exceptions: in one case of leukæmia we found 0·4 μgm. of biliverdin per c.c., while in one case each of pernicious

anæmia and obstructive jaundice (pancreatic carcinoma) the concentration of pigment was at the lowest limit of optical measurement.

It would appear, therefore, that choleglobin production from oxyhæmoglobin does not take place in the normal erythrocyte, and this and subsequent changes to form biliverdin can only ensue after disruption of the corpuscle.

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Origin of Noble Sugar-Canes (*Saccharum officinarum* L.)

The cultivated sugar-canes belong to two main groups: (1) the thin and hardy types of north Indian canes botanically classified under *Saccharum Barberi* Jesw. and *Saccharum sinense* Roxb.; and (2) the thick or noble types, *Saccharum officinarum*. The origin of these noble canes is still obscure, and Barber[1] and Jesweit[2] were of opinion that it was in the mountainous islands of the Malayan Archipelago, New Guinea and Polynesia. It is considered that these types of cane were introduced into India only very recently and are referred to as 'the introduced canes', while the north Indian canes are held to be indigenous to India and any mention of sugar-cane in India in early historical records or mythological legends is believed to refer only to north Indian canes.

Cytogenetical studies[3], supported by morphological evidence, have indicated that the north Indian canes are complex polyploid hybrids derived from the extensive natural hybridization of *S. officinarum* with *S. spontaneum* L., a related wild species which has a geographical distribution extending from the slopes of the Himalayas down to the tropical plains of Sumatra and Java. Therefore, it was concluded that the north Indian canes are of a later origin than the noble canes and that the thick canes must have been in cultivation in India earlier than the 'indigenous' or north Indian canes.

Studies are now in progress to identify the fundamental species composition of the noble cane, *S. officinarum*, which is considered to be an octoploid ($2n = 80$) with a basic number $x = 10$ characteristic of Andropogoneæ[4]. In interspecific and intergeneric hybrids with *S. officinarum* it is found that the haploid complement ($n = 40$) of *S. officinarum* pairs auto-syndetically to the exclusion of pairing between parental chromosomes. This was to be expected owing to the polyploid composition of the haploid complement itself. When, however, the chromosome complement of *S. officinarum* was reduced to the diploid and haploid number by successive back-crossing with the *Sclerostachya fusca* A. Camus, a wild species of a related genus, the homology between parental chromosomes began to manifest itself. Thus, with the diploid number, although ten bivalents of *S. officinarum* were commonly noticed, a certain number of multivalents resulting from the pairing of parental chromosomes were also noticed. In the haploid state it was clearly noticed that five chromosomes of *S. officinarum* invariably paired with five of the other parental species, thereby showing homology between them.

One of the types of the noble class of canes, namely, *Vellai* ($2n = 80$), was crossed with *Sclerostachya* ($2n = 30$) and the hybrid was successively back-crossed with the same wild species. The accompanying table gives in the main the analysis of chromosome associations at metaphase I of meiosis in the derived hybrids.

Association of chromosomes at metaphase I

	2n (number)	No. in the species complements of hybrids: *S. officinarum* (*O*)	No. in the species complements of hybrids: *Sclerostachya fusca* (*S*)	Pairing at metaphase I
Parents: *S. officinarum* (Vellai)	80			40^{II}
Scl. fusca	30			15^{II}
Hybrids: F_1 hybrid	55	40	15	$20^{II}(O) + 5^{II}(S) + 5^{I}(S)$
$F_1 \times$ *Scl. fusca* (back-cross I)	70	40	30	$20^{II}(O) + 15^{II}(S)$
B.C. I × *Scl. fusca* (back-cross II)	50	20	30	$10^{II}(O) + 15^{II}(S)$ $5^{III}(O+S) +$ $15^{II}(O+S) +$ $5^{I}(O)$
B.C. II × *Scl. fusca* (back-cross III)	40	10	30	$2^{IV}(O+S) +$ $21^{II}(O+S)$ $5^{III}(O+S) +$ $10^{II}(S) + 5^{I}(O)$

The basic number of ten chromosomes is now seen to be really constituted of two different sets of $x = 5$ chromosomes each, one set of which is common to both *Sclerostachya* and noble cane. A detailed account will be published elsewhere. The identification of these fundamental complements now remains to be investigated through a series of interspecific and intergeneric crosses by the utilization of the back-cross hybrids with the reduced complement of *S. officinarum*.

It is interesting to note that *Sclerostachya fusca* was originally included in the genus *Saccharum*[5], and later was separated as a different genus. This species is found widely distributed in India from Kashmir to Bengal and Assam and also in the Western Ghats. It is clear from the above studies that *S. officinarum* and *Sclerostachya* have had a common ancestry through an unidentified basic species with $x = 5$ chromosomes. This would lend further support to the view that *S. officinarum* has been in existence in India from very early times and that it played a part in the evolution of the north Indian or indigenous canes.

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Indian Agricultural Research Institute,
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Nov. 13.

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Occurrence of the Amphipod *Orchestia bottæ* and Other Organisms in Britain

THE range of *Orchestia bottæ* M. Edws. is greater than that indicated by Messrs. Cain and Cushing[1]. Besides the records from the Thames, I have specimens given me in 1945 by Mr. A. E. Ellis from the River Yare at Brundall, Norfolk. In 1947 I received specimens from the same area, but taken from much higher up the river, about twenty miles from the sea. In fact, it seems possible that this species is widely distributed throughout south-east England, and that recent discoveries disclose an established range rather than a late immigration from the Continent.

A similar case is that of *Eucrangonyx gracilis* (S. I. Smith), specimens of which I have from the Metropolitan Water Board's works at Lee Bridge; from a garden pond at Harrow (on the water system of the Colne Valley Water Co.); from ponds in Surrey; and lastly, in great abundance, from among floating dead leaves in a small backwater of the River Cherwell at Oxford in 1944.

Gammarus lacustris G. O. Sars has long been known to have a wide range in Scandinavian and other Continental fresh waters, and yet has only been discovered in Britain comparatively recently (1939). Despite this late discovery, persistent search has shown the species to be established in very many lochs in the north of Scotland, and so one concludes that it is really an old inhabitant.

In other words, it is not necessarily the range of some of these animals, I believe, that is increasing, but our knowledge of their range.

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[1] *Nature*, **161**, 483 (1948).

Discovery of Radioactivity

IN *Nature* of January 3, a review entitled "Atomic Energy" by Prof. J. A. Crowther referred to the progress made "since the spontaneous release of atomic energy fogged a packet of photographic material in the drawer of Becquerel's desk".

This sentence seems to imply that the discovery of radioactivity by Henri Becquerel, my father, in 1896, was fortuitous—which is incorrect. He intentionally subjected a photographic plate—not a "packet"—to the action of salts of uranium. His first idea was that phosphorescence of uranyl salts might be accompanied by a radiation similar to X-rays, which had just been discovered. Instead of rays associated with phosphorescence, Henri Becquerel found a new spontaneous radiation, emitted by all uranium compounds, phosphorescent or not, and he established that this radiation was an atomic property.

Hence it is undesirable that any idea of radioactivity being discovered by chance should arise.

JEAN BECQUEREL

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Paris.

I AM surprised that Prof. Becquerel should have read into a passing reference to his distinguished father's work, in my review of Prof. Gamow's book, a suggestion that the discovery of radioactivity was in any way "fortuitous". No such suggestion was intended. I had always imagined that the historic photographic plate was enclosed in some sort of light-proof wrapping, and might be legitimately, if briefly, described as a "packet of photographic material".

J. A. CROWTHER

Operational Research

IN his admirable article on operational research in *Nature* of March 13, Sir Charles Goodeve makes the statement: "The application of the statistical tool is still on the increase, but there is no need or likelihood of the tool itself being developed further". Quite apart from the dangers inherent in making general prophecies about the likely advance (or lack of advance) in any field of science, this statement implies a degree of perfection in existing methods of dealing with statistical problems arising in operational research which would not, I think, be claimed by practising statisticians. In particular, the analysis of data (such as survey data) which can be classified in a number of different ways, and multivariate analysis, both require further development.

In the analysis of survey data it is often of considerable importance to determine differences between the different classes of any one classification, free from the disturbing effects due to disproportionate representation in the other classifications. The basic theory (that of fitting constants by the method of least squares) is well known, but no analytical technique suitable for routine application to extensive data has yet been worked out. In multivariate analysis, which is of the greatest interest in economics as well as in many other fields, progress in both theory and analytical technique may be expected.

The dependence of the development of any given technique of statistical analysis on the availability of suitable machines is often not sufficiently realized. Without the modern desk calculator, the development of the technique of the analysis of variance appropriate to experimental results, and the associated development in the theory of design of experiments, could scarcely have taken place. In like manner, multivariate analysis has been waiting on the further development of machine design which is only now being effected.

With Sir Charles Goodeve I confidently look forward to the introduction of novel methods primarily dependent on advances in other fields of science; but if these are to reach their maximum effectiveness they must be integrated with, rather than regarded as alternatives to, the statistical approach.

F. YATES

Statistical Department,
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Harpenden, Herts.
March 23.

I AM grateful to Dr. Yates for correcting false impressions which may arise from my remark. Operational research as I have seen it has so far found the statistical tool adequate for that side of its work, but I might have guessed that there would always be 'frontiers' with unexplored fields or unsolved problems beyond.

CHARLES GOODEVE

FORMATION AND BREAKDOWN OF SERPULID TUBES

By JEAN HANSON
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DURING an investigation of the blood systems of serpulid worms (Annelida, Polychæta), opportunities occurred to make the following observations on the mode of formation and breakdown of the calcareous tubes in which these animals live.

Although much research has been carried out on the asexual reproduction of *Salmacina* and *Filograna* by Malaquin, Faulkner[1] and others, it is not known how a newly formed individual leaves its parent's tube and makes its own tube. During last summer, specimens of *Salmacina incrustans* Claparède settled on the sides of a glass aquarium in the Zoological Station at Naples, and daily observations were made on the growth of the colonies. The new individual is formed at the posterior end of the parent, and after separation it moves backwards down the parent's tube and makes a hole in the side of the tube from which it protrudes its branchial crown (Fig. 1, *X*). It may destroy the posterior end of the parent's tube and thus separate it from the rest of the colony (*Y*). It may also form a new tube which grows out from the original opening (*Z*). These colonies spread out over the wall of the aquarium. Colonies taken from the sea usually consist of masses of entangled tubes raised off the substratum to which the basal parts are attached. These three-dimensional colonies are built up of tubes with side-branches which are presumably formed in the same way as in the two-dimensional colonies growing in the aquarium.

It is not known how the newly separated bud makes the hole in the side of its parent's tube. One is reminded of the ability of the sabellid *Potamilla* to bore into calcareous rocks[2]. At Naples *Potamilla* often lives inside the walls of the calcareous shell of the mollusc *Vermetus*. How *Potamilla* bores its holes is also unknown. Some observations of Fox[3,4] are interesting in this connexion. He has found that when the anterior end of the tube of *Sabella spallanzanii* is artificially closed, the animal can make a hole in the side of the tube, from which it then protrudes its branchial crown. The tube of *Sabella* consists largely of mucus and is not calcareous.

Alkaline phosphatase is probably concerned in the calcification of bone and in the formation of the calcareous shells of molluscs[5]. It was therefore interesting to find this enzyme in *Pomatoceros triqueter* L. (Fig. 2) which, like the other serpulids, builds a calcareous tube. When *Pomatoceros* is removed from its tube, it begins to form a new one[6]. The new tube first appears on the ventral surface of the anterior part of the thorax under the ventral collar fold. It is not known how this new tube is produced; but it seems likely that it is secreted by glands in this part of the thorax.

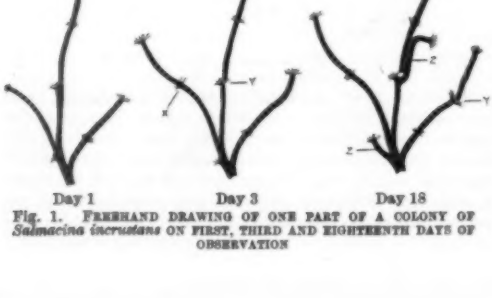

Fig. 1. FREEHAND DRAWING OF ONE PART OF A COLONY OF *Salmacina incrustans* ON FIRST, THIRD AND EIGHTEENTH DAYS OF OBSERVATION

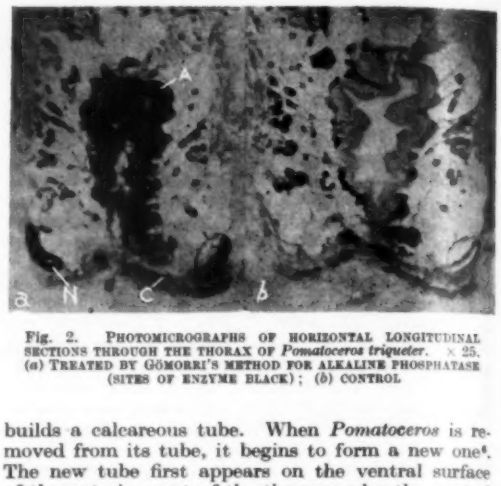

Fig. 2. PHOTOMICROGRAPHS OF HORIZONTAL LONGITUDINAL SECTIONS THROUGH THE THORAX OF *Pomatoceros triqueter*. × 25. (*a*) TREATED BY GÖMÖRI'S METHOD FOR ALKALINE PHOSPHATASE (SITES OF ENZYME BLACK); (*b*) CONTROL

One specimen of *Pomatoceros*, fixed immediately after removal from its tube, was sectioned and tested for alkaline phosphatase by Gomori's method[7]. The enzyme was found in the following places:

(1) The epithelium of the alimentary canal (Fig. 2, *A*) from the posterior end of the œsophagus to within a few segments of the anus. This is the part of the alimentary canal concerned with the digestion and absorption of food[8]. Phosphatase was concentrated at the inner and outer borders of the cells and was also found in the nuclei and in small granules in the rest of the cytoplasm. There was a thick deposit of phosphatase on the cilia. Bourne[8] has shown that the enzyme is confined to the absorptive regions of the guinea pig's alimentary canal and is there concentrated in the brush borders of the epithelium. He has discussed the hypothesis that alkaline phosphatase is concerned in the phosphorylation of sugars being absorbed from the canal.

(2) The epithelia of the thoracic nephridia (Fig. 2, *N*) and their ducts. In the excretory sacs of the nephridia the phosphatase was distributed in the same fashion as in the gut epithelium, and was also present on the cilia. Alkaline phosphatase has been seen in the brush borders of the proximal convoluted tubules of the mammalian kidney[7] and in the brush borders of the Malpighian tubules of the goat-moth caterpillar and a spider[9]. Danielli[7] has discussed the suggestion that in the kidney alkaline phosphatase plays a part in the reabsorption of substances from the glomerular filtrate.

(3) The contents of the alimentary canal.

(4) The chloragosomes (yellow- or brown-coloured globules) in the chlorogogen cells which in serpulids lie on the thoracic ring vessels. Globules of similar appearance, also giving a positive phosphatase reaction, are found in the epithelium of the excretory sacs of the thoracic nephridia. According to Liebmann[10] chloragosomes contain food substances, and he has found that in the chloragosomes of the oligochæte *Eisenia fœtida*, phospholipins are transformed into fats, lipoproteins appearing as transitional substances. Alkaline phosphatase may play some part in this process.

A second specimen of *Pomatoceros* was fixed three days after it had been removed from its tube; it had not begun to form a new tube. Alkaline phosphatase was again found in the same four sites as in the other specimen, and also in the following places (Fig. 2):

(5) The borders of small irregular cavities (*C*) situated in the thick epithelium on the ventral surface of the thorax under the ventral collar fold. This is the tissue which probably secretes the calcareous tube, and alkaline phosphatase is perhaps concerned in this process, as it seems to be in the calcification of bone and in the formation of the calcareous shells of molluscs[5].

(6) The epithelium of the dorsal and ventral lips of the mouth.

(7) The nuclei of the endothelium in the walls of the blood vessels in some of the pinnules of the branchial crown. Bourne[5] has found the enzyme in endothelial nuclei of vertebrate capillaries.

I wish to thank the staff of the Zoological Station of Naples, the British Association for the Advancement of Science for the use of its Table, and the University of London for a grant towards travelling expenses. I am also indebted to Dr. A. Stock for advice on the use of Gomori's method.

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PLANT VIRUS PROTEINS AND ANTIBODY–ANTIGEN REACTIONS

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PROTEIN mixtures such as those found in blood have been widely used in the study of antibody–antigen reactions. It is difficult to prepare pure samples of single proteins from such naturally occurring mixtures. On the other hand, preparations of certain plant virus proteins, derived from a single infectious unit, can be isolated in quantities sufficient for experimental work in a state which fulfils all the usual criteria of homogeneity. As they are also good antigens, they would appear to be especially suitable objects for the study of antibody–antigen reactions.

The method used by Boyd[1] has been applied to the study of the turnip yellow mosaic virus antisera produced in rabbits. Successive doses of 0·01, 0·1, 1·0, 10·0, and 100·0 mgm. of turnip yellow mosaic virus[2] (prepared by the method of Markham and Smith[3]) were given intravenously to a single rabbit. Bleedings were taken two weeks after each injection, followed by a rest period of a few days before the next injection.

The antiserum produced by the 0·01 mgm. injection was of low titre with marked suppression of precipitation in the region of antiserum excess. This antiserum would be of the *H* type according to Boyd's classification. With increasing dosage of antigen the antiserum produced gave progressively higher titres,

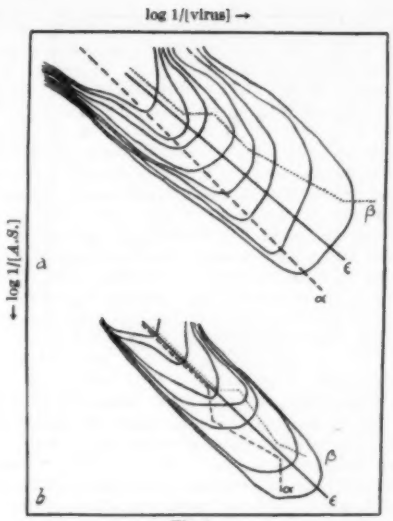

Fig. 1

and the type of precipitating system produced tended progressively towards Boyd's *R* type, with less-marked inhibition in the region of antiserum excess.

Fig. 1*a* shows the precipitating system for the antiserum produced after the 0·01 mgm. plus 0·1 mgm. injections. Fig. 2 shows the system for the antiserum from the same rabbit after the full course of injections.

If this antiserum obtained after the full course of injections is diluted with normal serum to make its titre approximate to one of the earlier antisera obtained, then the type of system produced approximates fairly closely to that produced by the earlier bleeding. For example, the antiserum obtained after the full course of injections (with a titre of 1 : 8192) was diluted to 1 : 256 with normal serum and a precipitation diagram prepared (Fig. 1*b*). This antiserum precipitated to a titre of 1 : 64, and there was fairly marked inhibition in the region of antiserum excess similar in amount to that found for the antiserum of Fig. 1*a* with a titre of 1 : 128.

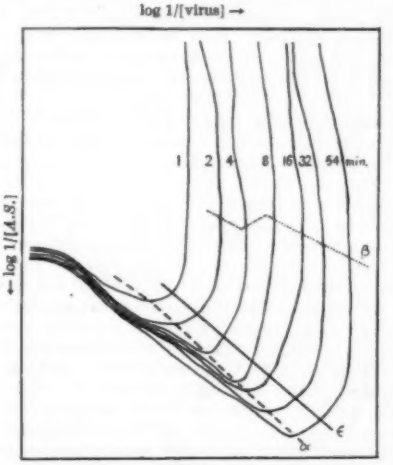

Fig. 2

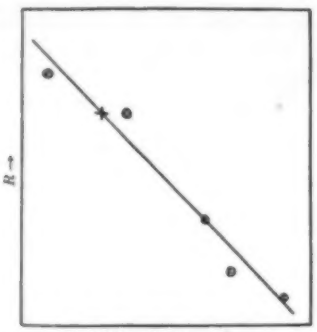

Fig. 3

The lowest concentration of virus which gives a precipitate is in general independent of the antiserum used, at antiserum dilutions where there is no inhibition by antiserum excess. The maximal inhibition by antiserum excess occurs with antiserum at 1 : 1. The ratio between the lowest concentration of virus giving precipitation with antiserum at 1 : 1 to the true virus end-point concentration gives a value for the amount of inhibition by excess antiserum which can be used to compare various antisera.

In Fig. 3 the ratio

$$R = \frac{[V] \text{ for antiserum at } 1:1}{[V] \text{ at real virus end point}},$$

where $[V]$ is end-point concentration of virus in mgm./ml., is plotted against the titre of the antiserum for the five sera used.

The point marked with a cross in Fig. 3 shows the position of the antiserum of Fig. 1*b*.

The inhibition in the region of antiserum excess shown in Fig. 1*b* can be due only to the presence of the non-specific constituents of the normal serum. On this account and in view of the close correlation between titre and amount of inhibition in the region of antiserum excess, it is suggested that the phenomenon of inhibition in the region of antiserum excess, the type of isochrones produced in this region, and the occurrence and position of the β-optimum, can be largely accounted for by some non-specific effect of normal serum constituents, at least in the system under investigation. Any theoretical consideration of the mechanism of this reaction, in the region of antiserum excess, will have to take this fact into account.

Rod-shaped plant viruses give a flocculent *H*-type precipitate whereas the spherical plant viruses give a dense granular *O*-type (Bawden[4]). Advantage has been taken of this fact in an investigation of the type of antiserum produced by a protein mixture. A rabbit was given a single intravenous injection of 1 ml. containing 1 mgm. of turnip yellow mosaic virus plus 1 mgm. of tobacco mosaic virus. An antiserum reacting with both viruses was obtained after two weeks. The same rabbit was given a second dose of 16 mgm. of each virus and a second antiserum obtained, of higher titre. These two antisera were tested against each virus separately, and against a mixture of known amounts of these.

That the two systems were precipitating independently was indicated by the following facts: (1) The position of the two α-optima for the two systems precipitating together was that which could be predicted from the two systems precipitating singly. (2) No significant decrease in titre of the antiserum for one virus was obtained after absorption with the other. (3) In the case of the two systems precipitating together, where the times for precipitation of the two systems were widely different in a single tube, the faster precipitate settled in the tube before the second precipitate formed, so that the latter formed a layer on top of the first.

In tubes where both systems precipitated about the same time, particularly in the higher concentrations, the gross floccules which were observed were homogeneous, and of indeterminate type. In view of the above, it is considered that this may possibly be due to mechanical entanglement of the smaller aggregates.

It is considered that, for the system studied, the antibodies produced in the rabbit are specific for the individual proteins of the mixture injected, and that in the *in vitro* reaction the two systems precipitate independently, except under conditions where the times for precipitation of the two systems are approximately the same, especially with high concentrations of the reagents.

A full account of these and other results will appear elsewhere. I wish to record my thanks to Dr. Roy Markham for his helpful encouragement and criticism.

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THE DISORDERING OF β-BRASS BY COLD WORK

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THE order–disorder transformation in β-brass has received much attention in recent years. However, it has not yet been found possible to obtain the disordered state at room temperature by quenching. Furthermore, an attempt to produce the disordered state by cold work[1] has not been successful, because the maximum amount of deformation which could be given to the pure β-brass was only 9·5 per cent reduction in area by drawing.

Since crystals of β-brass can be very heavily deformed when embedded in crystals of the more ductile α-phase[2], the use of a duplex brass provides a more likely way of producing the disordered state in β-brass. The X-ray method of showing the existence of the super-lattice in the case of β-brass presents great experimental difficulties; consequently we have used the electrical resistivity of the alloy to indicate its state of order. If the order is destroyed by cold work, an increase in resistivity is to be expected, by analogy with experiments which have been made with other alloys[3].

Lengths of duplex brass wire containing 41·3 per cent zinc were annealed for 30 minutes at 800° C., then furnace-cooled to room temperature over a period of 12 hours. This treatment resulted in a coarse structure in which the α- and β-phases were present in approximately equal proportions. The wires were then cold drawn to various reductions in area up to 95·5 per cent, and the electrical resistivities were measured on a Kelvin double bridge within two hours of drawing.

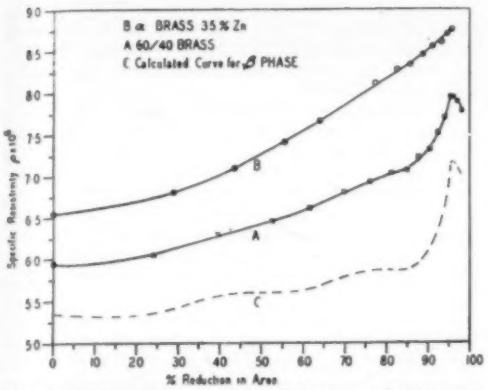

Fig. 1. SPECIFIC RESISTIVITY OF COLD-DRAWN α AND α + β BRASS WIRES

In Fig. 1 (curve *A*) the electrical resistivity is plotted against the degree of deformation. The resistivity increases with deformation, at first almost linearly, but more rapidly at higher deformations. After 95 per cent reduction in area, the specific resistivity had increased by about 33 per cent. At still higher deformations the resistivity slightly decreased.

To determine the individual behaviour of the α- and β-phases in the duplex wire, a similar series of measurements was made on a single-phase brass wire containing 35·1 per cent zinc, which is approximately the zinc content of the α-phase in the duplex brass. The results are shown in Fig. 1 (curve *B*). Although the resistivity of the α-brass also increases markedly with deformation, there is no rapid increase after heavy deformations. Assuming that the duplex alloy consists of equal parts by volume of each phase and that the α-phase in it behaves in the same way as the α-phase wire, then the behaviour of a wire consisting entirely of the β-phase can be deduced (Fig. 1, curve *C*). This curve indicates that the resistivity of the β-phase changes little up to 85 per cent reduction in area, where the curve turns steeply upwards. After 95 per cent reduction in area, the curve begins to fall.

In order to ascertain that this increase at high deformations was not a result of cracking, the wires were annealed in hydrogen at 800° C. for 30 minutes and furnace-cooled, that is, they received the same treatment as before deformation. Thus no difference

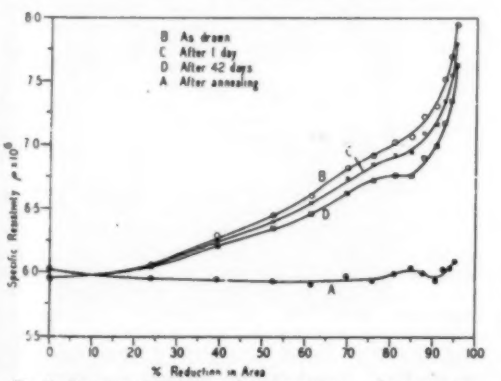

Fig. 2. SPECIFIC RESISTIVITY OF COLD-DRAWN α − β BRASS WIRES

in the distribution of the two phases should have occurred. The results of resistivity measurements on the annealed wires are shown in Fig. 2 (curve *A*), which indicates that all the wires have specific resistivities close to that of the original wire prior to drawing. Moreover, microscopic investigation showed no evidence of cracking, and the mere fact that the wires can be drawn still further points in the same direction. Thus the steep increase in resistivity of the duplex wires after heavy deformations can only be attributed to the disordering of the β-phase. After 95 per cent reduction the β-phase has apparently become completely disordered when further cold work has little effect on the resistivity. That this occurs only after an unusually high extent of total deformation is probably due to the fact that in the duplex alloy the β-phase receives a smaller fraction of the deformation than the ductile α-phase.

The resistivity of the duplex wire decreased with time after drawing. Fig. 2 shows the resistivity on drawing (*B*, corresponding to Fig. 1 *A*) after one day (*C*) and after forty-two days (*D*). It will be seen that after forty-two days the increase in resistivity produced by intensive cold work has decreased by 20 per cent. Further experiments showed that this recovery was in fact complete after twenty-seven days, and a subsequent decrease in resistivity after a period of seventy-nine days was only just measurable. In contrast with these results on duplex wires, α-phase wires showed no pronounced recovery, any decreases being of the order of ½ per cent six days after drawing. It is thus concluded that the β-phase is responsible for the changes in resistivity with time of the drawn duplex brass wires. The disordered state produced in the β-brass is presumably not completely stable, and a certain degree of re-ordering occurs at room temperature.

The marked change in resistivity produced by working a single-phase brass wire (35 per cent zinc) is also interesting. We found that the resistivity of brass wires of other compositions also increased, although that of pure copper did not. This fact is in contrast to statements made in the literature[4] that the electrical resistivities of terminal solid solutions are not affected by cold work. It does not seem improbable that a certain degree of order exists in α-brass and even in other α-solid solutions.

The work described above was carried out as part of the programme of the Section of Tribophysics, of the Council for Scientific and Industrial Research, Australia.

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ROOFS SUPPORTED BY AIR PRESSURE

By HERBERT H. STEVENS, JUN.
1270 Sixth Avenue, New York 20

ROOFS supported by air pressure are being seriously considered for long-span building construction as the result of tests conducted at New York University for the United States War Production Board in 1944.

Flat, circular membranes, fixed around the periphery, were stretched above the elastic limit by air

pressure to shallow dome shape, and were tested for load-bearing properties and stability at slight, continuously maintained pressures. Neither unsymmetrical loading on sheet steel models up to 12 ft. in diameter nor wind-tunnel tests disclosed undesirable features.

Besides theoretical studies of stress and strain distribution in the membrane, construction features and experience obtained with actual pressure-supported roofs were investigated. One of these structures was a semi-cylindrical roof, 25 ft. radius, 200 ft. long, built of 22-gauge sheet steel on formwork which was supplanted by 0·5 lb. per sq. in. air pressure after the ends were closed with a flexible connexion and the floor rendered airtight. This structure was built in 1934 at Minneapolis and was used as a 70,000-bushel grain bin for a year, after which it was dismantled because grain dust in suspension constituted an explosion hazard. Another structure investigated was a series of flexible-roofed inflated gas holders built of thin steel plates up to 300 ft. in diameter.

Because air-supported roofs offer enormous spans with the minimum of structural materials, they have caused considerable interest. The aeroplane manufacturer, Glenn L. Martin, proposed an 800-ft. diameter roof for a football stadium at Baltimore in 1945, shortly before the construction of amusement structures was forbidden by the U.S. Government. This roof was to have been of 52–SO aluminium alloy 0·109 in. thick with welded seams, and was to be supported by 0·06 lb. per sq. in. (gauge) air pressure maintained by ordinary ventilating fans discharging into the enclosure formed by the walls and ground. Entrance and exit were to be by revolving doors, and means were included for raising the pressure to balance snow loads and to supply power in case of power failure. The roof membrane was to be anchored to a concrete compression ring around the periphery of the stadium having sufficient strength to withstand the inward pull of the membrane to its yield strength. The membrane was to be formed by air pressure to finished shape from a somewhat flatter constructed shape. This would relieve stresses in the welded seams and tight spots in the membrane, and constitute a proof test of the structure. The air pressure to do this was calculated to be about 0·22 lb. per sq. in., a pressure of small physiological importance, and one obtainable with the ventilating blowers. This pressure would be about that needed to support 2·5 ft. of snow; and the roof capable of containing this pressure would also be capable of withstanding the lifting effect of a wind velocity of 125 miles an hour. These figures were based on the experiments previously mentioned. It was also found with a flutter model in the wind tunnel that a slight excess pressure maintained in the structure prevents rippling or flutter of the roof.

A number of other buildings using this roof have been considered, although none, so far, has been built. These include smaller structures about 300 ft. in diameter in which the circular anchor ring is carried overhead on columns and the building space extended underneath to fill out the corners of the lot. Structures ranging upwards to 1,800 ft. in diameter for industrial buildings, storage warehouses, commercial and amusement structures where clear span and low cost were important factors have been investigated. It was discovered that such structures could probably be built over the poorest of soils, since the roof loads were evenly transmitted to the floor and not concentrated at the footings. Another factor of interest is that positive pressure within the structure precludes outside air leakage into the building, making exceptional control of the interior atmosphere possible.

A weatherproof transparent plastic of possible use for these roofs is being developed in the United States. If the material, now in pilot-plant construction, is satisfactory, the utility of these roofs would be enormously extended. An unofficial group in Washington, D.C., is investigating the use of a transparent roof over a central courtyard surrounded by a block of apartments for human habitation, and following a suggestion of Prof. J. D. Bernal, a group in Salt Lake City, Utah, is investigating its possibilities for the growing of plants in waterless areas where the moisture may be conserved by the roof. The possibilities of extending the food-growing areas of the world by a technique involving little more than the cost of the plastic and the anchoring means might be of great importance. Likewise the possibility of inexpensively separating large areas from the prevailing atmosphere, and rendering them climatically inhabitable, may have considerable effect in the tropics.

A British Patent 591985 has been allowed on this construction and is endorsed Licence of Right.

PRODUCTION OF AN ANTIBIOTIC SUBSTANCE ON WHEAT STRAW AND OTHER ORGANIC MATERIALS AND IN THE SOIL

By ERNA GROSSBARD

Experimental and Research Station, Cheshunt

MANY soil micro-organisms produce under artificial conditions antibiotic substances which inhibit the growth of certain plant pathogens. On the assumption that a similar process may take place in the soil, investigations on this problem were commenced at the Research Station, Cheshunt, and an attempt made to devise a method whereby antibiotic substances will be produced abundantly in the soil for the purpose of controlling soil-borne diseases. Blair[1], Garrett[2], Millard and Taylor[3], West and Hildebrand[4], Sanford[5], and others, have reported that organic manuring reduced the incidence of certain soil-borne diseases and have suggested that microbial antagonism may be one of the important factors.

Our experiments here have shown that certain micro-organisms known to produce antibiotic substances on synthetic media, such as *Aspergillus clavatus*, *Aspergillus terreus*, *Penicillium patulum* and *Streptomyces antibioticus*, will do so when grown on autoclaved wheat straw to which water has been added[6].

Penicillium patulum has been studied in detail, because patulin (clavacin), the antibiotic substance produced by it, has a considerable inhibitory effect on the growth of certain plant pathogens[6,7,8,9]. The organism grew well on sterilized soil, but aqueous soil extracts did not inhibit the growth of the test organisms *Bacterium coli*, *Bacillus mycoides* and *Bacterium phytophthorum*. An antibiotic substance was formed, however, when the fungus was grown on sterilized wheat straw, bracken and sugar beet

TABLE 1

Medium	Diameter of area of inhibition (mean to nearest mm.)
Straw and water	20
Straw and water and 3·5% glucose	27
Sugar beet waste and water	29
Bracken and water	17
Bracken and 3·5% glucose and water	27

waste. The addition of glucose (3·5 per cent by weight) increased the inhibitory action of the wheat straw and bracken cultures. The undiluted culture fluid was assayed by the cylinder plate method. The plates were bulk-seeded with a 1 : 10 suspension of *B. mycoides*.

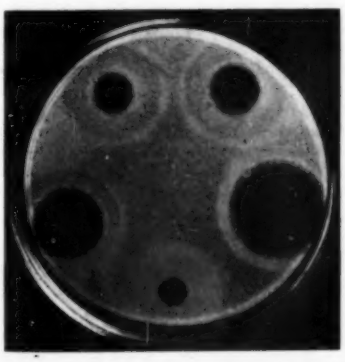
Among plant pathogens inhibited by the culture fluid of *P. patulum* grown on wheat straw and water were *B. carotovorum*, *B. aroideæ*, *B. phytophthorum* and several species of *Phytophthora*. There are indications that a number of other phytopathogens are also sensitive.

Autoclaved composted wheat straw when inoculated with *P. patulum* gave an antibiotic substance only in the presence of glucose. This also applied to peat, and to some extent to fescue, lucerne, mustard and sainfoin. Without glucose, cultures on the four latter materials gave inconsistent results varying with the sample used. In general, the inhibitory agent appeared to be rather unstable. Fescue gave the best results.

Experiments were then made to determine whether an antibiotic substance could be produced within the soil. Fresh wheat straw, 5 per cent, and water, 50 per cent by weight, were mixed with oven-dried soil, autoclaved and inoculated with *P. patulum*. After incubation the liquid expressed from the soil was assayed against *B. coli*, *B. mycoides* and *B. phytophthorum* by the cylinder plate method. It completely inhibited the growth of the test organisms.

A decrease in the quantity of wheat straw reduced the inhibitory action on the test organisms, while the addition of glucose greatly increased it. When straw was omitted and glucose (2 per cent) added, figures were only slightly lower than those obtained, for example, from a soil, straw (2·5 per cent) and glucose (2 per cent) medium (see photograph, Table 2).

It appears that carbohydrate decomposition is an essential factor for the production of an antibiotic



VARIATIONS IN THE ZONES OF INHIBITION. CYLINDERS WERE FILLED WITH SAMPLES OF MEDIA *a*—*e* (TABLE 2). AN UNDILUTED SUSPENSION OF *B. mycoides* WAS USED. NOTE ALSO ZONES OF STIMULATED GROWTH

TABLE 2

Medium	Inhibition of *B. mycoides* (1 : 10 suspension)	Diameter of area of inhibition
(*a*) Soil and water	None	—
(*b*) ,, ,, and 2·5% straw	Partial	12
(*c*) ,, ,, and 5% straw	Complete	15
(*d*) Soil, water and 2% glucose	Complete	21
(*e*) ,, ,, and 2·5% straw	Complete	26
(*f*) ,, ,, and 5% straw	Complete	28

substance in sterilized soil by *P. patulum*. A sterilized medium loam such as was used in this experiment may be an adequate substratum for the growth of the fungus; but it does not provide the conditions necessary for the production of an antibiotic substance. Yet as a matter of precaution it should be said that the absence of an inhibitory agent in the liquid expressed from the soil is not conclusive evidence that the antibiotic substance has not been formed at all. At low concentrations adsorption may take place. Garrett, West and Hildebrand, and Sanford have found that the addition of glucose to the soil decreased the incidence of certain diseases. These workers suggested that glucose effected a favourable modification of the microflora of the soil.

Glucose or other sources of carbohydrates such as wheat straw appear to be necessary for the manufacture of an antibiotic substance by *P. patulum*, at least in sterilized soil. It is tentatively suggested that, apart from altering the microflora, glucose may, in addition, induce the production of antibiotic substances in the soil not only by *P. patulum* but also by other micro-organisms.

This work has been carried out with a grant from the Agricultural Research Council. I am greatly indebted to Dr. W. F. Bewley, director of the Experimental and Research Station, Cheshunt, for guidance and advice.

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SEISMOLOGICAL RESEARCH IN GREAT BRITAIN

THE report of the British Association Seismological Committee to Section A (Mathematics and Physics) at the Dundee meeting in September 1947 covers a wide field of work during the period 1942–47.

During the war years, much of the time of the staffs of British seismological stations was devoted to war work. At Kew the three Galitzin instruments and the short-period vertical seismograph were maintained continuously. The Wood–Anderson seismographs were discontinued in May 1942, but were restarted for the Heligoland explosion of April 18, 1947. One of these is to be sent on loan to the Royal Observatory, Helwan. The analysis of seismograms is complete to date, and the Kew monthly bulletin, discontinued in May 1940, is being restarted. During the War, information on the recording of flying bomb

and other explosions was supplied to Government departments, and help was given to the Admiralty Research Laboratory at Teddington for studies on the correlation of water-waves and microseisms. At Bidston, the seismograph was maintained so far as possible throughout the War, but at times the supply of paper for recording ran out. At Durham, continuous recording ceased from July 1, 1939 until December 31, 1945. The observatories at Aberdeen, Stonyhurst and West Bromwich were kept going by Dr. A. E. M. Geddes, Rev. J. P. Rowland, and Mr. J. J. Shaw, respectively, as has also the Jagger shock recorder at Comrie, thanks to Messrs. W. Macbeth, Bruce, White and Clark. At Edinburgh the seismograph has been maintained in operation throughout the war years, but in view of the pressure of other work no readings from the records have been made since August 10, 1939. Mr. E. W. Pollard has continued his seismograph at Binstead, Isle of Wight.

Natural earthquakes occurred in Great Britain on December 30, 1944, at Skipton in Yorkshire, and at Spean Bridge (Scotland) on Christmas Day, 1946.

Use of Explosives

A Joint Committee of the Royal Society and the Ministry of Supply was formed early in 1946 to investigate the use of surplus explosives for seismological purposes. It was found impracticable to detonate large charges in Britain, but observations have been made on explosions in Germany. Very thorough arrangements were made for the observation of the results of the detonation of about 6,000 tons of explosive at Heligoland on April 18, 1947, and the seismograph records are being studied at Cambridge, in Germany, and by the U.S. Naval Ordnance Laboratory. From Cambridge, also, parties are examining the cross-sections of steep-sided valleys filled with glacial deposits south of Cambridge, in the Lake District and in Wales. A method has also been evolved of carrying out controlled explosions in the water at sea for seismic purposes, but at present there is some difficulty in borrowing a ship.

International Seismological Summary

The work on the International Seismological Summary has now moved from the University Observatory, Oxford, to its temporary home at Kew Observatory, Richmond, Surrey. It is intended that it shall find in due course a permanent home at Cambridge. As the final part of the work from Oxford, Miss E. F. Bellamy, who has just retired, has published an Index Catalogue of Epicentres for 1931–35. This is a supplement to the Index Catalogue 1913–30. The epicentres are arranged by latitude and longitude into four groups: N. and E.; N. and W.; S. and E.; S. and W.; and the date for each shock is given. At the end of the paper two valuable maps on Mollweide equal-area projections are given showing the epicentres. Seismologists will be indebted to Miss E. F. Bellamy, Prof. H. H. Plaskett and the University Observatory at Oxford for the work and for meeting the cost of the printing, also to the American Museum of Natural History for the outline maps. As the first instalment of the work from Kew, the International Seismological Summary for the period January, February, March 1936 has been issued. This contains the readings from observatories, epicentres in geographic co-ordinates and initial times for 116 earthquakes, eight of which are deep-focus earthquakes. The task of bringing this, the final word anywhere on any earthquake, more up to date is formidable. The United Nations Educational, Scientific and Cultural Organisation is expected to contribute funds, and then with sufficient computational assistance the work can be brought as near to date as observatories can send in their final readings of seismograms.

Applied Seismology

In the realm of applied seismology we have the use of the seismograph to obtain news of storms at sea, and in prospecting for minerals, including mineral oil. Both these ways of utilizing seismological methods are being actively employed in Great Britain. The work on the correlation of sea waves and microseisms carried out by the Admiralty has been described by Dr. G. E. R. Deacon, in *Nature* (**160**, 419; 1947); taken in conjunction with the work of the Jesuit Seismological Association, St. Louis, U.S.A., it is a most important piece of work. This work is being followed up by the Admiralty, by the Jesuit Seismological Association and by the U.S. Coast and Geodetic Survey.

Exploration for oil by the seismic method has been going on for some time. Artificially produced earthquakes are sent through the surface layers of the earth, which, if they have sufficiently diverse elastic properties, affect the waves in such a way that, after making certain assumptions, the character and thickness of the layers may be deduced from the readings of the seismograms. The seismic method is thus used to locate structures such as closed anticlines or domes of porous material likely to contain mineral oil, capped by impervious shale which prevents the escape of the oil. The 'refraction shooting' method has been used largely in Great Britain, but 'arc shooting' by the Anglo-Iranian Oil Co. was the deciding factor in the opening up of the Eakring oilfield in Millstone grit sandstones capped by the coal measure shales of Nottinghamshire, which has produced to date more than 100 million gallons of oil. Traces of mineral oil have also been found in the Cretaceous and Jurassic strata in the south of England, but attempts to extract oil from the Mesozoic beds have proved disappointing.

The search for oil by geophysical means has incidentally discovered new coalfields in Great Britain. In the search for coal, extrapolations are carried out from known geological facts, and the likely areas are then surveyed in order by (1) magnetic, (2) gravity, (3) seismic methods; and if the area passes all these tests it is then drilled. The magnetic survey is quick and easy to carry out, and gives a broad outline of the structure provided there is a marked magnetic property associated with the structure. The gravitational survey will give an idea of the variation in density in the underlying strata, and is rapid and easy to carry out with such instruments as the Frost gravimeter which is, in effect, a very sensitive spring balance. The seismic method takes longer and is more expensive, but gives a better idea of the underlying structure.

So far, an extensive coalfield has been verified by boring to 4,000–5,000 ft. in Central Lincolnshire, and it is hoped that the measures will rise as they approach the Wash. Coal measures have been disproved by a boring at North Creake in north Norfolk. Seismic surveys have been completed in the vicinity and to the west and south-west of Market Drayton in Shropshire, and between here and Burton-on-Trent. Gravity and magnetic surveys

have been carried out in Wiltshire as an eastern continuation of the Somerset Coalfield, or there may be an independent coalfield, in the Cotswold country of Gloucestershire and in southern Worcestershire, and in certain areas in Oxfordshire—between Oxford and Reading. Work in eastern Essex was also contemplated. In all the above areas there is a possibility of coal being found. Other areas are under consideration, including extensions of present known coalfields.

UNITED NATIONS CONFERENCE ON THE CONSERVATION AND UTILIZATION OF RESOURCES

A REPORT by the Secretary-General of the United Nations, presented as a result of the decision of the Economic and Social Council on March 28, 1947, to call a Scientific Conference on the Conservation and Utilization of Resources, for the purpose of exchanging information on techniques in this field, their economic costs and benefits and their interrelations, recommends that the Conference should be held in the United States during May 16–June 3, 1949. A note on the financial implications is being prepared on the assumption that it will be held at Lake Success; but possibilities of another location are being explored. Four classes of participants in the Conference are contemplated: representatives from Government services, members of non-Government services and individuals selected by member Governments; individual specialists selected with the advice of the Preparatory Committee to prepare papers or to lead discussion, invited by the Secretary-General, in consultation with the Governments concerned; representatives of the United Nations and its specialized agencies; and representatives of interested international organisations and learned societies, and distinguished members of the professions, to be admitted at the discretion of the Secretary-General.

The primary concern of the Conference is with the practical applications of science to public administration and human needs, rather than with minute refinements in research and scientific methodology, and the Conference should serve a uniquely important function by bringing together experts from many related fields. About half the time of the Conference will be given to primary sessions on subjects of general interest such as resource requirements for industrialization, the contribution of improved agriculture to living standards, the planning of multiple use development of regional resources, education in conservation, and the sources and methods for mobilization of capital and man-power for resource development. Technical sessions in the remaining half of the programme will give experts concurrent opportunity of exchanging information on minerals, fuels, power, water, soils, crops, livestock, forests, fish and wild-life, and though primarily devoted to the discussion of methods for the development of natural resources, will reflect the importance in such developments of techniques relating to standards of health and living. Particular attention will be devoted to the special problems of the under-developed countries.

These technical sessions may be expected to stimulate the economic development of such countries by defining the technical knowledge gained in the last decade in determining the resource requirements for various types of industrialization, by exploring the technical problems involved in raising the standard of living by increased agricultural production, by considering the institution of new techniques and by the modification of existing curricula to facilitate the provision of trained personnel in such countries and by directing the attention of the scientific men and technicians of the world to the research and design problems of these areas. A draft programme is being prepared for circulation to all members of the United Nations for comment, and the Secretary-General also proposes to establish a standing Preparatory Committee as well as to convene in certain regions informal meetings of experts. The Economic and Social Council is also being requested to establish a small temporary Consultative Committee representing about six member Governments.

FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Tuesday, April 20

ROYAL SOCIETY OF ARTS, DOMINIONS AND COLONIES SECTION (at John Adam Street, Adelphi, London, W.C.2), at 2.30 p.m.—Mr. A. J. Wakefield: "The New East African Ground Nuts Scheme".

SOCIETY OF CHEMICAL INDUSTRY, AGRICULTURE GROUP (in the Chemistry Department, Royal College of Science, Imperial Institute Road, London, S.W.7), at 2.30 p.m.—Dr. W. G. C. Forsyth: "Carbohydrate Metabolism in Soil".*

ROYAL ANTHROPOLOGICAL INSTITUTE (at 21 Bedford Square, London, W.C.1), at 5 p.m.—Colonel D. H. Gordon: "The Prehistoric Cultures of the Zhob and the Indo-Iranian Connexion".

INSTITUTE OF PHYSICS, ELECTRONICS GROUP (at 47 Belgrave Square, London, S.W.1), at 5.30 p.m.—Dr. C. J. Milner: "Long-Wave Infra-Red Detectors".

INSTITUTION OF CIVIL ENGINEERS (at Great George Street, London, S.W.1), at 5.30 p.m.—Mr. E. A. G. Johnson: "Flooding in the Fens and Remedial Measures Taken".

MANCHESTER GEOGRAPHICAL SOCIETY (in the Geographical Hall, St. Mary's Parsonage, Manchester), at 6.30 p.m.—Mr. L. Brooks: "Geography in Education and Citizenship".

OIL AND COLOUR CHEMISTS' ASSOCIATION (at the Royal Society of Tropical Medicine and Hygiene, Manson House, 26 Portland Place, London, W.1), at 7 p.m.—Mr. K. McTaggart: "Esters of Titanium".*

ROYAL PHOTOGRAPHIC SOCIETY, SCIENTIFIC AND TECHNICAL GROUP (at 16 Prince's Gate, London, S.W.7), at 7 p.m.—Symposium on "Modern Techniques in Stereoscopy".

SHEFFIELD METALLURGICAL ASSOCIATION (at 198 West Street, Sheffield), at 7 p.m.—Mr. F. Turner: "Some Applications of the Supersonic Frequency Detector in Steelworks Inspection".

SOCIETY OF DYERS AND COLOURISTS, SCOTTISH SECTION (at St. Enoch Hotel, Glasgow), at 7 p.m.—Mr. G. H. Lister: "An Investigation into the Practical Aspects of the Absorption of Acid and Chrome Dyes by Wool".

BRITISH POLISH SOCIETY (at the Polish Institute, 81 Portland Place, London, W.1), at 8 p.m.—Prof. S. Loria: "The Organisation of Scientific and Cultural Life in Wroclaw".*

Wednesday, April 21

TEXTILE INSTITUTE (in the Council Chamber, Town Hall, Macclesfield), at 12 noon.—Annual General Meeting: at 2.30 p.m.—Mr. Allan Walton: "Art in relation to the Textile Industry" (Mather Lecture).

INSTITUTE OF FUEL (at the Institution of Mechanical Engineers, Storey's Gate, London, S.W.1), at 2.30 p.m.—Dr. D. T. A. Townend: "Recent Developments in Combustion".*

ROYAL SOCIETY OF ARTS (at John Adam Street, Adelphi, London, W.C.2), at 2.30 p.m.—Sir Robert Robinson, P.R.S.: "The Structural Relationships of some Plant Products" (Trueman Wood Lecture).

ROYAL INSTITUTE OF CHEMISTRY, LONDON AND SOUTH-EASTERN COUNTIES SECTION (at the London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1), at 4 p.m.—Symposium on "Laboratory Layout and Construction".

GEOLOGICAL SOCIETY OF LONDON (at Burlington House, Piccadilly, London, W.1), at 5 p.m.—Scientific Papers.

ROYAL METEOROLOGICAL SOCIETY (at 49 Cromwell Road, London, S.W.7), at 5 p.m.—Dr. H. G. Booker: "Some Problems of Radio-Meteorology" (Symons Memorial Lecture).

ROYAL MICROSCOPICAL SOCIETY (in the Hastings Hall, B.M.A. House, Tavistock Square, London, W.C.1), at 5.30 p.m.—Dr. E. S. Horning: "Researches on Cosmic Radiations at the High Alpine Scientific Station, Jungfraujoch"; Dr. E. P. George: "Physical Properties of Cosmic Radiation".

BRITISH INSTITUTION OF RADIO ENGINEERS, SCOTTISH SECTION (at the Institution of Engineers and Shipbuilders in Scotland, Elmbank Crescent, Glasgow), at 6.45 p.m.—Mr. J. B. Birks: "The Physical Applications of Microwaves".

SOCIETY FOR VISITING SCIENTISTS (at 5 Old Burlington Street, London, W.1), at 7.30 p.m.—Discussion on "The Publication and Classification of Scientific Knowledge" (Speakers: Sir David Chadwick, Prof. J. D. Bernal, F.R.S., Dr. Alexander King and Dr. H. T. J. Ellingham).

Thursday, April 22

ROYAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 4.30 p.m.—Dr. A. N. Drury, F.R.S.: "The Lister Institute of Preventive Medicine".

LINNEAN SOCIETY OF LONDON (at Burlington House, Piccadilly, London, W.1), at 5 p.m.—Dr. B. Barnes: "White Flowers in *Ranunculus Flammula* Linn."; Prof. W. E. Le Gros Clark, F.R.S.: "A Review of the African Fossil Primates discovered during the Year 1947".

LONDON MATHEMATICAL SOCIETY (at the Royal Astronomical Society, Burlington House, Piccadilly, London, W.1), at 5 p.m.—Prof. J. G. van der Corput: "Properties of Rationality in Geometry".

INSTITUTION OF ELECTRICAL ENGINEERS (at Savoy Place, Victoria Embankment, London, W.C.2), at 5.30 p.m.—Dr. B. H. C. Matthews, F.R.S.: "The Nervous System as an Electrical Instrument" (Thirty-ninth Kelvin Lecture).

CHEMICAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 7.30 p.m.—Mr. H. King: "Curare Alkaloids—Constitution of *dextro* tubocurarine Chloride and its Botanical Origin"; Mr. P. Oxley, Mr. M. W. Partridge, Mr. D. A. Peak, Mr. T. D. Robson and Mr. W. F. Short: "New Methods for the Preparation of Amidines".

Friday, April 23

ROYAL ASTRONOMICAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 4.30 p.m.—Geophysical Discussion on "Solar Radio Noise".

CHEMICAL SOCIETY, NEWCASTLE AND DURHAM SECTION (at King's College, Newcastle-upon-Tyne), at 5 p.m.—Prof. Linus C. Pauling: "The Valence of Metals and the Structure of Intermetallic Compounds" (Bedson Club Lecture).

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS (at the Mining Institute, Newcastle-upon-Tyne), at 6.15 p.m.—Prof. A. F. Burstall: "The Work of the Engineering Department in a University".

ROYAL STATISTICAL SOCIETY, INDUSTRIAL APPLICATIONS SECTION (at the Mining and Technical College, Crumlin, Mon.), at 6.30 p.m.—Dr. B. P. Dudding and Mr. W. J. Jennett: "Applied Statistics and Industrial Efficiency".

Saturday, April 24

INSTITUTION OF CHEMICAL ENGINEERS, NORTH-WESTERN BRANCH (in the Reynolds Hall, College of Technology, Manchester), at 3 p.m.—Mr. S. H. Wilkes: "Dust Explosions in Factories".

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

RESPONSIBLE LECTURER IN ELECTRICAL ENGINEERING—The Principal, Royal Aircraft Establishment Technical College, Farnborough, Hants (April 24).

LECTURER or ASSISTANT LECTURER IN THE DEPARTMENT OF PHYSICS—The Registrar, The University, Sheffield (April 24).

ASSISTANT LECTURER IN PHYSICS—The Principal, Municipal College of Technology, Manchester (April 26).

PROFESSIONAL OFFICER (Plankton Research), DIVISION OF FISHERIES, Department of Commerce and Industries, Cape Town—The Secretary, Office of the High Commissioner for the Union of South Africa, Trafalgar Square, London, W.C.2 (April 30).

LECTURESHIPS and SENIOR LECTURESHIPS IN PHYSICS—The Secretary of University Court, The University, Glasgow (April 30).

MUSEUMS ASSISTANTS in the Victoria and Albert and Science Museums—The Museum Superintendent, Science Museum, or Victoria and Albert Museum, South Kensington, London, S.W.7 (May 1).

LECTURER or ASSISTANT LECTURER IN THE DEPARTMENT OF CIVIL ENGINEERING—The Registrar, The University, Sheffield (May 1).

REGISTRAR, and a LIBRARIAN, of University College, Gold Coast—The Secretary, Inter-University Council for Higher Education in the Colonies, 8 Park Street, London, W.1 (May 1).

TECHNICIAN (male) IN THE PATHOLOGICAL DEPARTMENT of the West Midland Forensic Science Laboratory, Birmingham—The Establishment Officer, Home Office, Room 297, Whitehall, London, S.W.1 (May 10).

CHAIR OF BACTERIOLOGY at St. Mary's Hospital Medical School—The Academic Registrar, University of London, Senate House, London, W.C.1 (May 12).

CHAIR OF PHYSIOLOGY at London Hospital Medical College—The Academic Registrar, University of London, Senate House, London, W.C.1 (May 13).

SENIOR ASSISTANT IN THE ACADEMIC DEPARTMENT of the Headquarters Administrative Staff—The Principal, University of London, Senate House, London, W.C.1 (May 15).

PROFESSOR IN CIVIL ENGINEERING at Ceylon Technical College—The Ceylon Government Representative, 28 Cockspur Street, London, S.W.1 (May 15).

ASSISTANT LECTURER IN THE DEPARTMENT OF PHYSICS—The Secretary, Bedford College for Women, Regent's Park, London, N.W.1 (May 20).

DEMONSTRATOR IN THE DEPARTMENT OF GEOLOGY—The Secretary, Bedford College for Women, Regent's Park, London, N.W.1 (May 21).

ASSISTANT LECTURER IN THE DEPARTMENT OF ZOOLOGY AND COMPARATIVE ANATOMY—The Registrar, University College of South Wales, Cathays Park, Cardiff (May 31).

CHAIR OF STATISTICS at the London School of Economics and Political Science—The Academic Registrar, University of London, Senate House, W.C.1 (May 31).

ASSOCIATE PROFESSOR OF ANATOMY (Sub-Department of Human Embryology and Histology) at the University of Queensland, Brisbane—The Agent-General for Queensland, 409 Strand, London, W.C.2, or the Secretary, Universities Bureau of the British Empire, 8 Park Street, London, W.1 (Brisbane, May 31).

PROFESSOR OF PHYSIOLOGY, and a PROFESSOR OF ANATOMY, in the University College of the West Indies—The Secretary, Special Committee of the Senate on Higher Education in the Colonies, University of London, Senate House, London, W.C.1 (June 1).

LECTURER IN PERSONNEL PRACTICE in the Department of Social Studies, University of Melbourne—The Secretary, Universities Bureau of the British Empire, 8 Park Street, London, W.1 (Melbourne, June 30).

NUFFIELD FELLOWSHIPS FOR EXPERIMENTAL AND THEORETICAL RESEARCH IN NUCLEAR PHYSICS—Professor of Natural Philosophy, The University, Glasgow, W.2 (June 30).

SENIOR LECTURER IN BOTANY at Victoria University, Wellington, New Zealand—The Secretary, Universities Bureau of the British Empire, 8 Park Street, London, W.1 (Wellington, June 30).

FISHERIES OFFICERS in Malaya—The Director of Recruitment (Colonial Service), 15 Victoria Street, London, S.W.1.

DESIGN ENGINEERS and PLANNING ENGINEERS IN THE DEPARTMENT OF ATOMIC ENERGY (Production)—The Staff Section, Ministry of Supply, Department of Atomic Energy, Risley, Warrington, Lancs.

LECTURER IN BIOLOGY—The Clerk to the Governing Body, Battersea Polytechnic, Battersea, London, S.W.11.

SCIENTIFIC AND TECHNICAL LIAISON OFFICER of the International Wool Secretariat for its North American Section, New York—The Secretary, International Wool Secretariat, 18 Regent Street, London, W.1.

LECTURER IN RADIO ENGINEERING—The Clerk, Northern Polytechnic, Holloway, London, N.7.

PHYSICAL CHEMIST or PHYSICIST to undertake fundamental work on metal finishing problems, including electro-deposition and electro-polishing—The Secretary, British Non-Ferrous Metals Research Association, 81–91 Euston Street, London, N.W.1.

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Federation of American Scientists. The Purposes of the F.A.S. Pp. 8. (Washington, D.C.: Federation of American Scientists, n.d.) [77

Questions and Answers about Atomic Energy. Pp. 32. (Washington, D.C.: National Committee on Atomic Information, n.d.) [77

I'm a Frightened Man. By Dr. Harold C. Urey. Pp. 8. (Washington, D.C.: National Committee on Atomic Information, n.d.) 5 cents. [77

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Radiology: being Section 14 of Excerpta Medica. Vol. 1, No. 1, June. Pp. 58. (Amsterdam: N.V. Excerpta Medica, 1947.) 15 dollars; 75*s.* per year. [107

Carnegie Institution of Washington: Department of Terrestrial Magnetism. Publication 578: Description of the Earth's Main Magnetic Field and its Secular Change, 1905–1945. By E. H. Vestine, Lucile Laporte, Caroline Cooper, Isabella Lange and W. C. Hendrix. Pp. v + 532. (Washington, D.C.: Carnegie Institution, 1947.) 2.50 dollars. [157

International Institute of Agriculture. International Yearbook of Agricultural Statistics, 1941–42 to 1945–1946. Vol. 1: Agricultural Production and Numbers of Livestock. Pp. xxiv + 245. 1.50 dollars. Vol. 2: International Trade. Pp. xi + 570. 3 dollars. Vol. 3: Apportionment of Areas, Agricultural Production and Numbers of Livestock in various Countries. Pp. vii + 328. 2 dollars. (Rome: International Institute of Agriculture, 1947.) [157

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International Journal of Opinion and Attitude Research. Published Quarterly. Vol. 1, No. 1, March. Pp. ii + 144. (Mexico: Dr. Laszlo Radvanyi, Donato Guerra 1, Desp. 207; London: Social Research Publications, Ltd., 1947.) 1.25 dollars; 4 dollars a year. [227

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